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PRODUCT ENGINEERING

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PRODUCT ENGINEERING

VOLUME 6 NUMBER 12

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Next Month

Books on the construction of charts and nomograms treat the subject purely mathematically. All that most engineers want to know is how to make the charts. This is exactly what the series of articles on the construction of charts, beginning in the January number, will show. Written by M. G. Van Voorhis, well known to *P.E.* readers, the articles set forth the subject in simple language, with numerous illustrative examples.

In applying central lubrication, care must be taken so that every bearing will get its share of oil. In the second of his articles on lubrication, R.G.N. Evans shows how to do it.

The fifth of the series of Ketcham color articles, originally scheduled for this number, will appear in January. Illustrated in colors, it will give examples of some interesting color illusions.

Other articles include one on springs by J. K. Wood, materials for electric hearing elements, typical designs of flexible couplings, plus the regular departments.

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330 W. 42d Street, NEW YORK, N. Y.

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CONTENTS for DECEMBER, 1935

MODIFIED GEARS FOR INCREASED CENTER DISTANCE.... 442
HANS SCHEMM—How to determine maximum increase in center distance of a given pair of gears with shaper or hob cut teeth.

SEVEN RULES FOR GOOD APPEARANCE..... 446
A terse statement of the fundamental requirements for a clean-cut looking design.

LUBRICATION OF SLEEVE BEARINGS—I..... 448
R.G.N. EVANS—Introduction to a series of four articles on the application of means for providing lubrication.

TOLERANCES AND CLEARANCE LIMITS..... 453
F. J. POTTER—Dimensioning and checking bolt and stud holes with and without expressed tolerances.

BEARING METALS FOR SEVERE SERVICE—II..... 456
Concluding installment of the advantages, properties and limitations of recently developed bearing alloys.

CHARTS SIMPLIFIED BY USING DISTORTED COORDINATES.. 459
CARL P. NACHOD—A method for constructing straight-line charts for engineering design formulas.

FINISHING SPECIFICATIONS..... 463
Detailed specifications for cleaning and surface preparation for painting or lacquering.

PITTING OF STAINLESS STEEL BY LEATHER..... 465
J. N. SMITH—Conditions that cause it and how the use of inhibitors prevents the corrosion.

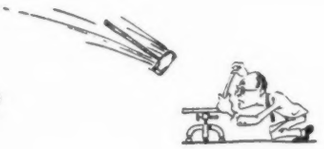
ANTI-FRICTION BEARINGS IN AUTOMOBILES—III..... 470
E. WOOLER—Last of a series of typical anti-friction bearing mountings for automotive applications.

LENGTH OF MATERIAL FOR 90-DEG. FORMS—I..... 479
J. K. OLSEN—First of three charts giving the developed length of sheet steel bends having 0.005 to 6 in. radii.

Editorial 441
Product Developments 450
Question and Comment..... 466
News 472
Meetings 473
New Materials and Parts..... 474
Manufacturers' Publications 477
Books and Bulletins..... 477

Published monthly. Price 35c. a copy. Subscription rates—United States, Mexico, Central and South American countries $3 a year. Canada, including duty, $3.50 a year. All other countries $5 a year or 20 shillings. Entered as second-class matter January 17, 1930, at Post Office at New York, N. Y., under the act of March 3, 1879. Cable address "McGrawhill, New York." Member of A.B.P. Member of A.B.C. Copyright 1935 by McGraw-Hill Publishing Co., Inc. Printed in U.S.A. by the Schweinler Press, N. Y.

Intimate Correspondence



A Good Idea

PRODUCT ENGINEERING
NEW YORK

Replying to yours of November 14, we want the reprints of your editorial "Give Them Credit" exactly as the sample copy you sent us. It is certainly a fine line of argument.

We get reprints from all such editorials in the machinery magazines and hand them out to all our men in the shop hoping that we can educate them so that they will understand that the only hope of putting men to work is for the manufacturing plants to have plenty of work so that they can employ men.

If all manufacturers in the United States would buy reprints as we are doing, the manufacturers would very quickly get over to every one of their working men or employees the correct point of view, showing on which side the working man's bread is buttered.

Why don't you send out a postal to your subscribers or a letter, asking them to distribute your editorials? The sooner we educate our employees, the more successfully will our factories be run and the quicker will be the return to prosperity. Why not give this thought serious consideration?

—P.H., *President*
Philadelphia, Pa.

MANY thanks for the fine compliment. The purpose of editorials is to formulate constructive ideas and opinions. When the editorial strikes a responsive chord, and extra copies are desired for distribution, we will be glad to cooperate in every way. P.H. is doing a real educational job in giving his employees reprints of editorials of the type to which he refers.

Bouquets

PRODUCT ENGINEERING
NEW YORK

We surely want to compliment you on the manner in which your survey of engineering activities was handled. The data given was of universal interest and was mighty comprehensive for the space which you were able to allot to that survey.

—J.D.Z., *Engineer*
Milwaukee, Wis.

And Brickbats

PRODUCT ENGINEERING
NEW YORK

The *Product Engineering* magazine for November 1935 is a "flop." I believe that the data given in about 30 pages could have been presented in about three pages very nicely.

—H.I.H., *Designer*
Fort Wayne, Ind.

HERE are two opposing views and tastes. But we wonder how many of our readers would have attached as much importance to a brief tabulation on three pages as they did to the survey report as presented. Merely the tables and charts alone would have robbed the presentation of some of its most interesting features. On the other hand, continuing the letter sent in by H.I.H., he writes:

"You show many neat designs but seldom show what goes on inside. How about some sectional views of these designs? I would like to know how the sheet metal is fastened and where the joints are located.

"I like your series on color and think that your magazine, *Product Engineering*, is the best of its type.

"During the four years that I have been taking *P.E.* I have gone from layout man to assistant to the chief engineer of a large works for which progress *P.E.* must receive some credit."

We confess that frequently we show neat designs without construction details, by force of necessity and space limitations. However, it is evident that H.I.H. desires more articles on sheet metal design. If this guess is correct, we will satisfy his desires in the near future. And thank you ever so much, H.I.H., for your fine compliment in crediting *P.E.* in part for your progress. We hope it continues.

Hydraulic Parts Wanted

PRODUCT ENGINEERING
NEW YORK

We have been much interested in the two articles, "Modern Hydraulic Systems for Operating Machinery," which appeared recently in *Product Engineering*.

We are considering the use of a hydraulic system on special automatic machines designed and operated by ourselves and are in need of information regarding such necessary items as hydraulic pumps, cylinders, valves, etc.

If it is within your service to supply us with a list of manufacturers of such parts, we would be greatly obliged.

—M.P.C., *Chief Engineer*
Waterville, Maine

OF course we are always glad to be of service to any readers who are up against it in finding sources of supply for machine units and parts. Our advertising pages are one source of such information; hydraulic pumps in this instance. For suppliers of hydraulic cylinders, valves and similar units, we obligingly sent M.P.C. a list.

Old But Good As New

PRODUCT ENGINEERING
NEW YORK

Referring to the April 1930 number of *Product Engineering*, pages 184 and 185, is an article "Stresses in Symmetrical Tubes." The last paragraph of the article reads as follows:

"In the next article examples will be given showing how, by the application of these equations to tubes whose cross-sections are hollow rectangles, the bending moments and stresses in such tubes may be calculated."

We are anxious to secure a copy of the issue subsequent to April 1930 wherein the application of these equations to hollow rectangular tubing is presented.

—J.W.H.
Barberton, Ohio

THE article in question appeared in the May 1930 number of *Product Engineering*. Here is an example showing the value of a clipping file of *Product Engineering* articles of major interest. And that is why we do our best to arrange the articles so that they can be clipped without destroying one another.

More Hydraulics

PRODUCT ENGINEERING
NEW YORK

We would like to obtain two extra copies of your magazine Vol. VI, No. 8 for August 1935 as we are interested in the article entitled "Modern Hydraulic Systems for Operating Machinery" which appeared on page 282.

—M.E.E., *President*
Racine, Wis.

More Colors

PRODUCT ENGINEERING
NEW YORK

Thank you for the reprints of Mr. Ketcham's color articles sent with your letter of September 12. I would also like to receive reprints of all future articles by Mr. Ketcham.

—J.D.E., *Asst. Director of Research*
Pittsburgh, Pa.

EVIDENTLY for many of our readers, one copy of *Product Engineering* is not enough. However, we are always glad to be of service in sending out tear sheets as long as the supply lasts.

Received With Thanks

PRODUCT ENGINEERING
NEW YORK

In regard to your journal, the writer is of the opinion that if you are in every instance as accurate in reporting an article as you have been in the article "Rhodium Surfaces for Metal Reflectors," appearing in your August number, that you have one of the most valuable journals I have ever come across, not only in this country but also in every other country that the writer has traveled in, and that is a good many. You certainly should be complimented in the way you are rendering valuable service to your subscribers.

—E.B., *President*
Belleville, N. J.

THAT'S covering a lot of territory and it is a compliment of which we feel proud, but we will not rest on such laurels. In fact, we recognize that credit should go to our contributors as well as the editors.

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

MCGRAW-HILL PUBLISHING CO., INC. DECEMBER 1935 VOLUME SIX, NUMBER TWELVE

Don't Blame the Purchasing Agent

THERE was a time when high-pressure-selling was the only accepted method. Engineering specifications were mere generalities. Iron was iron and steel was steel. Relatively little technical knowledge was required in selecting from among the products of leading manufacturers. High-pressure selling was the only recognized method. Usually the order went to the salesman who could string the best line of stories, order up the best meal and liquor, and furnish the most attractive and entertaining samples of femininity.

It so happens that there are still quite a few old-fashioned companies that have not awakened to the fact that the modern salesman of engineering parts and materials is not a mere peddler of wares and a professional entertainer. The sales engineer of today is a specialist in the thing that he has to sell. He is technically trained, and has experience of the broadest kind. He reaches into all the fields and types of industries that use his product. He is continually conferring with designing engineers and has seen the mistakes that have been made in the application of his products. He is a walking encyclopedia of special facts and information. Often he gives information about new design developments, but he respects confidences.

There are many examples of the benefits to be gained by giving the sales engineer access to the engineering department. The fact is, with the great technical strides of the last few decades, it is impossible for a layman to pass judgment upon the relative technical merits of competing products. Even if the purchasing agent be a technically trained men, he is not in sufficiently close contact with the operations of the engineering department to be able to make intelligent decisions solely on his own judgment. He must obtain the opinions of the chief engineer. And unless the chief engineer has had the opportunity of conferring with sales engineers of the various manufacturers, his opinion will be based upon incomplete information.

After the chief engineer has passed upon the relative merits of the competing products, let the purchasing agent wrestle with the price situation and place the orders. It is still, and probably always will be, the job of the purchasing agent to deal with the high-pressure salesman and be his entertained guest to the small extent to which this method of selling still exists.

When the purchasing agent requires the visiting sales engineer to get permission to interview the chief engineer, the purchasing agent is merely enforcing a prescribed routine. But when because of personal prejudice, false assumptions or ego, the purchasing agent arbitrarily refuses to permit the sales engineer to see the chief engineer, the situation is different.

EVERY manufacturer should see to it that the door of his chief engineer is open to the visiting sales engineers. And when the visiting sales engineer finds that his path to the engineering department is blocked by the purchasing agent, he should smother his natural feeling of animosity. It would be better to supplant it with a feeling of heartfelt sympathy for the chief engineer who is being deprived of the benefit of free consultation with specialists of industry.

MODIFIED GEARS for Increased Center Distance

The factors limiting the increase in center distance of a given pair of gears with standard hobbed or shaper cut involute teeth

HANS SCHEMM
Autocar Company

IN CUTTING special gears with a standard hob or a standard circular shaper, two factors limit the possible increase in gear outside diameter. The line of action cannot pass the addendum line, therefore the maximum increase is limited to the addendum distance. With any greater increase in outside diameter the flank of the hob tooth no longer is tangent to the involute tooth curve.

The second limiting factor is the decrease in tooth tip width as the hob or cutter is withdrawn. As it is not practical to operate gears with sharp teeth, for practical purposes the tip width should be no smaller than 10 per cent of the thickness of a standard tooth.

Both of these limitations depend on the number of teeth in the gear as well as the method of cutting the teeth. From the geometry of the involute tooth form the maximum increase can be determined, subject, of course, to such practical considerations as the strength and number of teeth in contact.

In using hob-cut gears, following the notation given in Fig. 1, the relation between v, the increase in tooth thickness and b the amount of cutter withdrawal is,

$$v = 2b \tan \phi \qquad (1)$$

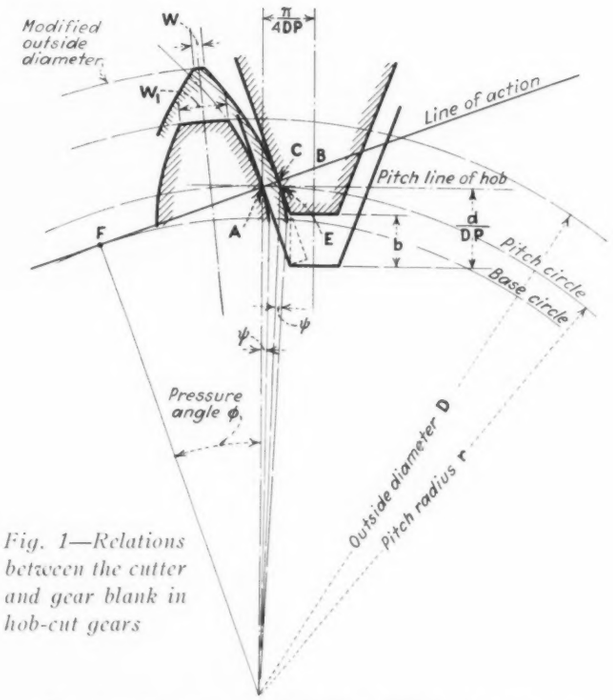
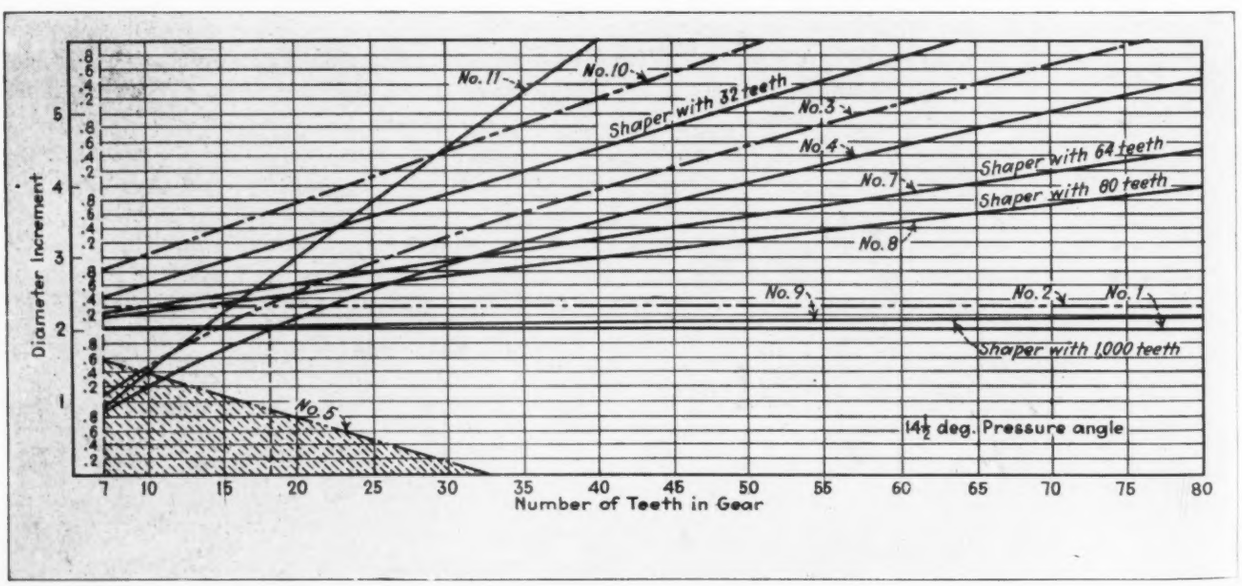


Fig. 1—Relations between the cutter and gear blank in hob-cut gears

Fig. 2—Maximum theoretical diameter increase for gears with 80 teeth or less and 14½ deg. pressure angle, for different conditions as explained in the text



From the maximum distance b, which is the addendum distance d divided by the diametral pitch $D.P.$, the maximum theoretical diameter increase, under the first limitation—keeping the line of action below the addendum line—is $2.3142/D.P.$ This condition for gears of 80 teeth or less is shown by *Curve 2* for a $14\frac{1}{2}$ deg. pressure angle in Fig. 2, and in Fig. 3 for a 20 deg. pressure angle. However, the hob tooth has a chamfer, and the practical increase in diameter cannot exceed $2/D.P.$ for hob-cut gears, which is shown as *Curve 1* in Fig. 2 and Fig. 3. Thus, the maximum increase in tooth thickness is,

$$v_{max} = \frac{2 \tan \phi}{D.P.}$$

The largest possible tooth thickness is,

$$\left(\frac{\pi}{2} + v_{max}\right)\frac{1}{D.P.} = \left(\frac{\pi}{2} + 2 \tan \phi\right)\frac{1}{D.P.} \qquad (2)$$

With this tooth thickness, the maximum outside diameter in terms of n, the number of teeth, is given by,

$$\frac{(n + 2 + 2b)}{D.P.} = \frac{n + 4}{D.P.} \qquad (3)$$

In determining the width of the tooth tip—the second limiting factor—the minimum tip width W' of the special gear is assumed to be 10 per cent of W_1, the tip thickness of a standard tooth. With a standard hob and standard tooth depth, the width of a standard tooth tip W_1 can be determined from the pressure angle ϕ, the generating angle ω for the involute curve, and ψ, the angle formed by the involute curve between the base circle and the pitch circle. Angle ψ is a constant equal to $\tan \phi - \phi$. For $14\frac{1}{2}$ deg. pressure angle, ψ is 19 min. 4 sec. and 51 min. 14 sec. for 20 deg. pressure angle. The generating angle ω in terms of the outside diameter D, the pitch radius r, and the pressure angle ϕ, is given by

$$\omega = \sqrt{\frac{D^2}{4r^2 \cos^2 \phi} - 1}$$

The tip width for a standard tooth is then,

$$W_1 = D \sin\left[\frac{\pi}{2n} + \psi - (\omega - \tan^{-1}\omega)\right] \qquad (4)$$

Where $M = (\omega - \tan^{-1}\omega)$, tip width W' for a modified gear with an increased outside diameter is given by,

$$W = \frac{1}{D.P.}(n + 2 + \cot \phi\, v) \sin\left[\frac{1}{n}\left(\frac{\pi}{2} + v\right) + \psi - M\right] \qquad (5)$$

For a value of $(n + 2 + \cot \phi\, v)/D$, for the outside diameter, the relation between v the increase in tooth thickness and the generating angle ω is,

$$\omega = \sqrt{\left(\frac{n + 2 + \cot \phi\, v}{n \cos \phi}\right)^2 - 1} \qquad (6)$$

Since the sine of a small angle is nearly equal to the arc of the angle, the tip width of the modified tooth can also be written,

$$W = \frac{1}{D.P.}\, n \cos \phi \sqrt{1 + \omega^2}\left[\frac{1}{n}\left(\frac{\pi}{2} + v\right) + \psi - M\right] \qquad (7)$$

The theoretical limitation for the amount of diameter increase is $W' = 0$, so that,

$$\frac{1}{n}\left(\frac{\pi}{2} + v\right) + \psi - M = 0 \qquad (8)$$

From Equation (6) the following relation can be obtained,

$$v = n \sin \phi \sqrt{1 + \omega^2} - \tan \phi\,(n + 2) \qquad (9)$$

Since ψ equals $\tan \phi - \phi$, this relation takes the following form after substituting these values in Equation (8) and solving for n.

$$n = \frac{\frac{\pi}{2} - 2 \tan \phi}{\phi - \sin \phi \sqrt{1 + \omega^2} + M} \qquad (10)$$

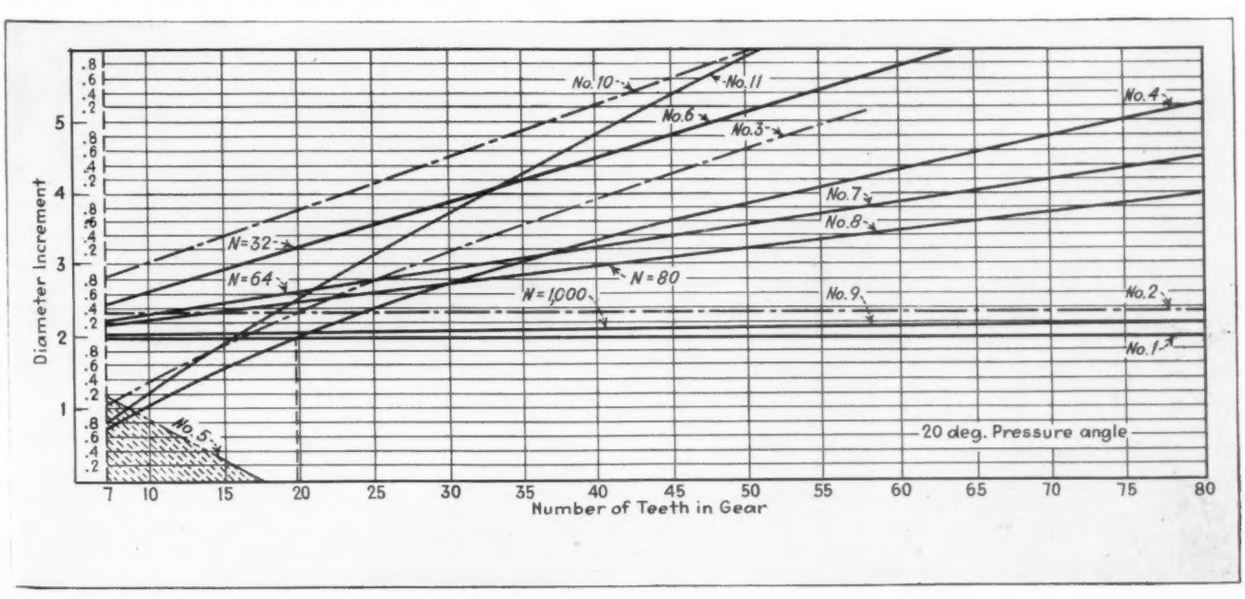
The modified outside diameter is,

$$D = \frac{1}{D.P.}\, n \cos \phi \sqrt{1 + \omega^2} \qquad (11)$$

For a condition giving sharp teeth, the increase in gear diameter is,

$$2b = \frac{1}{D.P.}\left[n \cos \phi \sqrt{1 + \omega^2} - (n + 2)\right] \qquad (12)$$

Fig. 3—Maximum theoretical diameter increase for gears with 80 teeth or less and 20 deg. pressure angle, for different conditions, as explained in text



Equations (10) and (12) are plotted as *Curve 3* on Fig. 2 for a 14½ deg. pressure angle, and on Fig. 3 for a 20 deg. pressure angle.

Since it is not practical to run gears with sharp teeth, it is assumed for practical purposes that H' should be no smaller than 10 per cent of the tooth thickness or $\pi/20$ *D.P.* Therefore, Equation (7) can be written,

$$\frac{\pi}{20\ D.P.} = \frac{n A}{D.P.}\left[\frac{1}{n}\left(\frac{\pi}{2} + v\right) + \psi - M\right] \tag{13}$$

In this equation,

$$A = \cos\phi\sqrt{1 + \omega^2}$$

Solving this relation for n, Equation (13) takes the form,

$$n = \frac{A\left(\frac{\pi}{2} - 2\tan\phi\right) - \frac{\pi}{20}}{A\left[\phi - \sin\phi\sqrt{1 + \omega^2} + M\right]} \tag{14}$$

Modified outside diameter and diameter increase can then be determined from Equations (12) and (14). The amount b that the hob will have to be withdrawn is,

$$b = \frac{1}{D.P.}\left[\frac{n}{2}(A - 1) - 1\right] \tag{15}$$

This maximum increment is shown as *Curve 4* on Fig. 2 and Fig. 3, for a minimum tip width of 10 per cent of the tooth thickness. Increment values are divided by the *D.P.* to obtain the diameter increase in inches.

The intersection of *Curves 1 and 4* for gears of slightly less than 20 teeth indicates that interference will result from the diameter increment that is suitable for 20 teeth or more. As the diameter increment of hob cut gears for this condition is $n\cos\phi\sqrt{1 + \omega^2} - (n + 2)$, which must be equal to $2d$, the value for n at the intersection is given by,

$$n = \frac{2d + 2}{\cos\phi\sqrt{1 + \omega^2} - 1} \tag{16}$$

After transforming and simplifying Equation (16) takes the form,

$$\sqrt{1 + \omega^2}\left[(2d + 2)\,M + (2d + 2)\,\phi + \frac{11}{20}\pi - 2\tan\phi\right]$$
$$= (1 + \omega^2)\left[\frac{\pi}{2}\cos\phi + 2d\sin\phi\right] + \frac{\pi}{20\cos\phi} \tag{17}$$

Substituting each of the two pressure angles, the value of n becomes 18.165 for a 14½ deg. pressure angle and 19.761 for a 20 deg. pressure angle. The generating angles are 0.7671 for the 14½ deg., and 0.7983 for the 20 deg. pressure angle.

To avoid interference, the hob must be withdrawn a distance b equal to $1 - \frac{1}{2}\,n\sin^2\phi$ for 1 *D.P.* The value of v is given by,

$$v = 2b\tan\phi = 2\tan\phi\left(1 - \frac{n\sin^2\phi}{2}\right) \tag{18}$$

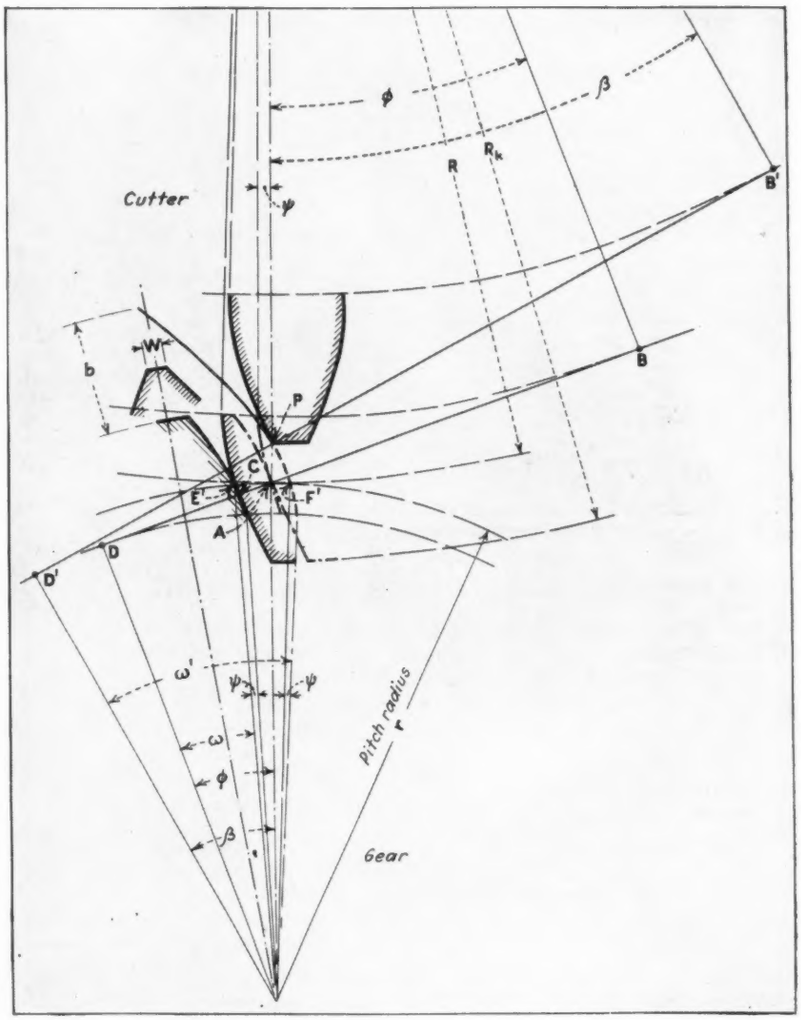


Fig. 4—Cutter and blank relations when a circular gear shaper is cutting a standard gear. The notations used in the text are indicated

By simplifying Equation (18) the following relation is obtained giving directly the minimum diameter increment for gears of 20 teeth or less.

$$2b = \cot\phi\, v = (2 - n\sin^2\phi) \tag{19}$$

The minimum diameter increment to avoid interference as given by Equation (19) is shown by *Curve 5* on both Fig. 2 and Fig. 3. Thus, to avoid interference in a gear with 10 teeth and 14½ deg. pressure angle the addendum must be increased so far that the gear has almost sharp teeth.

When using a circular gear shaper the fundamental principles outlined for hob-cut gears are employed. If a circular gear shaper cuts a standard gear, the line of action is normal to both curves as shown at A in Fig. 4. This is also the point of tangency of the two pitch circles and the intersection of the line of action and the center line. As the gear is modified and the center distance increased, the obliquity of the line of action changes. Circles through the intersection point of the new line of action with the center line are called operating pitch circles, because the involute curves are in contact at these circles. The point of tangency of the involute curves will be always on the center line and it can be seen that the maximum amount of withdrawal

will be reached when the line of action just passes through P, the intersection point of the shaper involute and its outside diameter.

Where β is the largest possible angle of obliquity, and N is the number of teeth in the shaper, Fig. 4 shows that,

$$\frac{R \cos \phi}{\cos \beta} = R_s$$

$$\cos \beta = \frac{R \cos \phi}{R_s} = \frac{N \cos \phi}{N + 2.3142} \qquad (20)$$

For practical purposes this relation can be arbitrarily assumed to be,

$$\cos \beta = \frac{N \cos \phi}{N + 2} \qquad (21)$$

A few practical values of β are given in the accompanying table. The value of $N = 1{,}000$ is cited, to show that for $N = \infty$ the curves coincide with those already developed for hobbing. In general, the value of β and the diameter increment, which is twice the amount of cutter withdrawal b, is given by,

$$\cos \beta = \cos \phi \frac{r + R}{r + R + b} \qquad (22)$$

$$b = \frac{1}{D.P.} \left(\frac{n + N}{2}\right) \left[\frac{\cos \phi}{\cos \beta} - 1\right] \qquad (23)$$

When Equations (20) and (21) are substituted in Equation (23), the maximum theoretical b_{th} and the maximum practical cutter withdrawal b_p, both being one-half the diameter increment is given by,

$$b_{th} = \frac{1}{D.P.} \left(\frac{n + N}{2}\right) \left[\frac{\cos \phi \,(N + 2.3142)}{N \cos \phi} - 1\right] \qquad (24)$$

$$b_p = \frac{1}{D.P.} \left(\frac{n + N}{N}\right) \qquad (25)$$

From these equations it is evident that when using a circular gear shaper the diameter increment is a function of the number of teeth in both the gear and in the gear shaper. *Curves 6, 7, 8* and *9* in Fig. 2 and Fig. 3 show the maximum practical diameter increments possible with shapers having 32, 64, 80 and 1,000 teeth. *Curve 10* represents the maximum theoretical diameter increment which is possible for a shaper with 32 teeth.

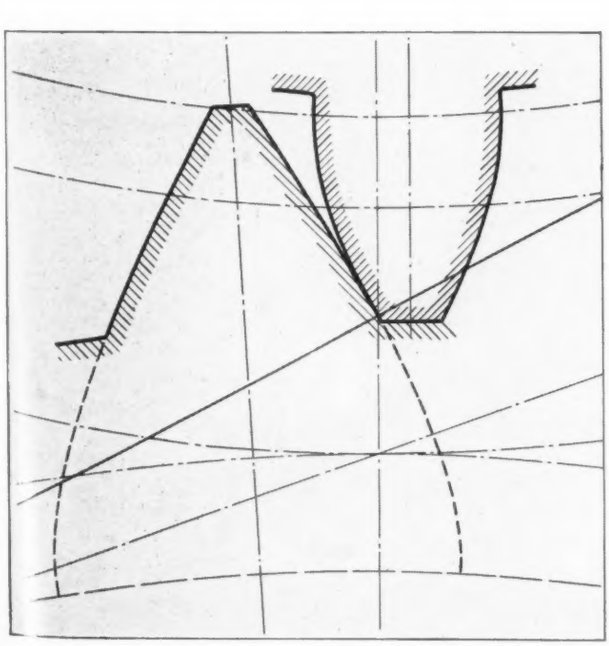


Fig. 5—A 40-tooth gear cut by a 32-tooth shaper withdrawn to produce the minimum tip width

The second limitation in increasing the diameter of shaper-cut teeth is the same as with hob-cut gears. The shaper can be withdrawn only until the tooth has a sharp edge at the outside diameter. Assuming again that the minimum tip width is 10 per cent of the tooth thickness, the following equations give:

$$\cos \beta = \cos \phi \frac{n + N}{n + N + 2b}$$

$$v = (n + N)(\tan \beta - \beta - \psi)$$

$$W = (n + 2 + 2b)\pi \left[\frac{1}{n}\left(\frac{\pi}{2} + v\right) + \psi - M\right] = \frac{\pi}{20} \qquad (30)$$

These equations can be solved by cut and try for the diameter increment $2b$, to obtain the minimum tip width for the number of teeth in the shaper. In Fig. 2 and Fig. 3 *Curve 11* is for a cutter with 32 teeth.

Corresponding curves for cutters with a greater number of teeth will lie between *Curves 11* and *4*, where *Curve 4* is the limit for a hob or a shaper having an infinite number of teeth. Curves for cutters having a smaller number of teeth will lie above *Curve 11*. Values in the chart are for 1 *D.P.* For other pitches values given are divided by the desired *D.P.*

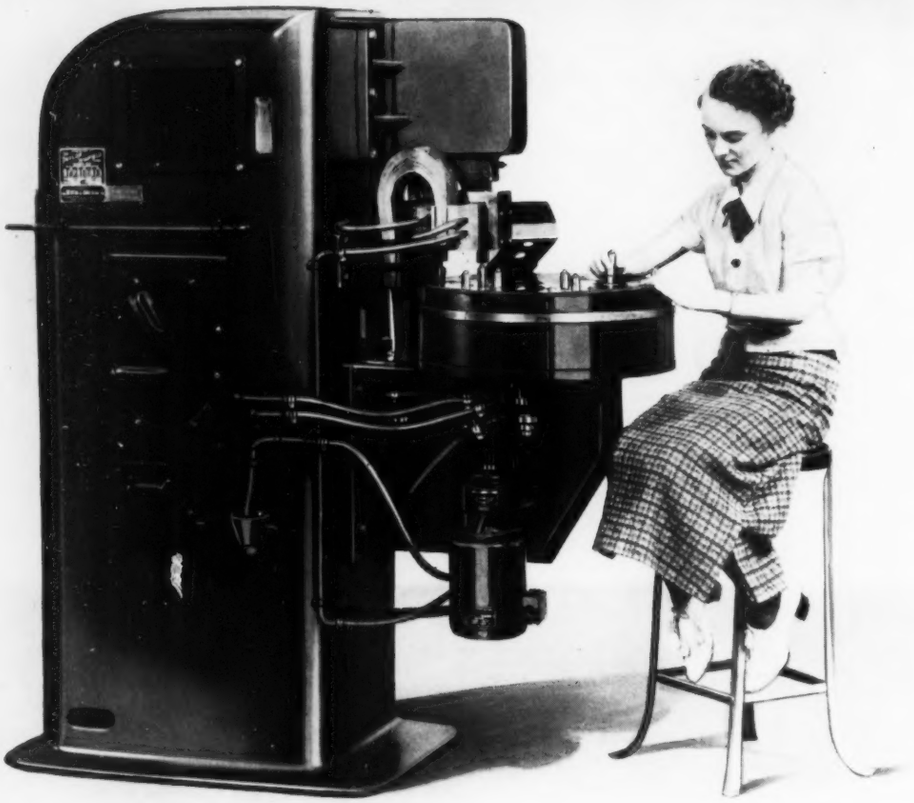
For reason of space the chart is limited to $n = 80$. Its extent can be increased easily as lines are straight and therefore can be extrapolated. To facilitate an extension for *Curve 4* the diameter increment for the following number of teeth can be used:

Pressure Angle	Number of Teeth	Diameter Increment
14½ deg.	311	13.31 in.
20 deg.	228	11.54 in.

For a gear with 40 teeth cut by a shaper with 32 teeth, Fig. 5 shows the tooth form when the cutter is withdrawn enough to result in a tip width of 10 per cent of the tooth thickness. The line of action is still normal to both curves, and the amount of withdrawal is still within theoretical limitation. However, the diameter increase is too much because of practical restrictions.

Oddities About Aluminum

- More than 500,000 lb. of aluminum foil has been used in lining beer bottle caps. This was fabricated in rolls 1⅛ in. wide and if the foil were unrolled, it would reach around the equator one and two-thirds times.
- Aluminum is the most abundant metal on the earth's crust and is the third most common element.
- The amount of electricity which is required to make a pound of aluminum would keep a 40-watt electric light burning for twelve days.
- The flakes of aluminum in aluminum paint are approximately one-tenth as thick as the walls of a soap bubble.
- Two of the oldest fabricated aluminum articles still in use are an engineer's transit and the 100-oz. casting which caps the Washington Monument. Both were made before electrolytic reduction of aluminum had been perfected.



Seven Rules

CYRIL DONALDSON
Rochester Athenaeum & Mechanics Institute

Although this Taylor-Winfield resistance welding machine has not been "styled," careful attention to detail and the use of simple lines, rounded corners and smooth surfaces gives an appearance of solidity and utility

GOOD looks do not make machinery work better. However, a machine is something more than a convenience. For instance, an automobile is something more than a conveyance; it is, in most cases, a treasured possession, a source of family pride—something that should give its owner pleasure whenever he looks at it.

The modern trend is to have professional artists or industrial designers called in to aid the machine designer. The wise draftsman will always try to understand the artist's ideas and will endeavor to incorporate as many of these as is possible. But the designing engineer should also attempt to incorporate into his original design the general requirements for attractive appearance with reference to form and proportions of the part.

There are a number of general rules that must be considered in striving for artistic appearance. Admittedly these rules are generalizations. But at the same time, it is by the application of these rules by men endowed with an artistic sense that attractive appearance of the product is developed. Seven rules may be quoted.

1—SIMPLIFICATION. This calls for genuine skill in design as it requires a redesign wherein unnecessary parts are eliminated or, as is more often the situation, wherein a single part is required to perform a number of functions. Several recent examples of simplification in automobile engine design include the Nash engine block wherein the manifolds are cast in one piece with the main block. This resulted in the elimination of several hundred parts. Another example is found in automobile engines wherein a single V-belt drives the fan, generators and two water pumps. In the first of these illustrations, parts were eliminated by consolidating several into one piece, thereby eliminating the connecting elements. In the second instance, the one part was arranged to serve a multiplicity of purposes.

A study of the elements of mechanical movements and mechanics is a great aid to the simplification of machines, but the greatest aid is common "machine sense," which comes only from experience.

2—SIMPLICITY OF FORM. Having simplified the design as a whole in order to attain the least number of elements and the simplest arrangement, the next step is to simplify the form of the various elements, as well as the machine as a whole. The eye likes a simple form which it can grasp without much effort, especially if the shape is symmetrical about at least one axis. Electrical generators, motors, and radial engines give pleasing effects because of symmetry.

3—FAMILIARITY OF SHAPE. Welded construction is often criticized as ugly because people are accustomed to the tapers and curves associated with castings. Similarly, designers will frequently make a dummy construction in order to avoid an unfamiliar appearance. The common example of this rule is the fitting of dummy funnels to ships driven by diesel engines. Many of the steam-driven ocean liners such as the Normandie, are also fitted with dummy funnels.

4—SUBORDINATE LINES SHOULD AGREE WITH DOMINANT SHAPE. If the frame of the machine is round, other lines should probably be concentric with it. If straight lines are necessary against a curved background, they should be radial or more or less tangential. Attachments to the main shape should agree with it and not be too abrupt at the transition. Observance of this rule is the chief reason for airplanes being so pleasing to the eye. This rule should be considered whenever it is necessary to add feet or brackets to a machine.

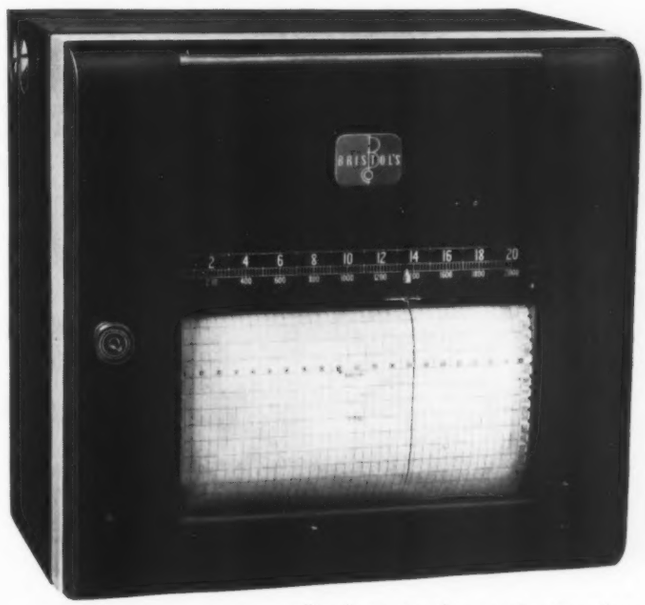
5—FUNCTION SHOULD DETERMINE FORM. The designer should always keep the job performed by the machine in his mind. For instance, a power shovel built along the lines of an airplane would be considered more ridiculous than beautiful, while at the same time it is possible for a rugged looking power shovel to give a pleasing appearance by reason of its huskiness.

for Good Appearance

Knowing the rules does not make an engineer an artist. But it does enable him to improve the appearance of his designs and helps him understand the problems of the industrial designer

6—THE GOLDEN PROPORTION. It has been recognized for years that the best looking rectangle has a certain fixed proportion; the short side is to the long side as the long side is to the sum of the two sides. Arithmetically, the short side is 61.8 per cent of the long one. Any ratio reasonably close to this gives a fairly good appearance and the designer should try to keep as close to this proportion as is practically possible.

7—PSYCHOLOGICAL EFFECTS OF SHAPES. An object that is high and narrow may look dignified or graceful, but it is likely to look weak. Designers should avoid shapes or structures that although actually sufficiently strong look as if they could not withstand the normal load to which they might be subjected. Similarly, mobile machines should not be permitted to look massive and clumsy.



Good proportion and attractive appearance were obtained by Joseph Sinel in styling Bristol's potentiometer pyrometer

Not only improved appearance but increased utility and convenience was the result of Wilbur Henry Adams' redesign of Berlay steel filing cabinets

A classical example of the psychological effect of shape is the design of the 1917 Fokker tri-plane in which the designer had skilfully avoided the necessity of using outside struts. He conclusively proved that the wings would carry many times the normal load, yet airplane pilots refused to fly this highly efficient machine because the wings looked too flimsy.

Recent surveys have proved that for most products appearance is the biggest factor in marketing products. Even though the company may have turned this phase of the design problem over to a professional industrial designer, it must be remembered that the designing engineer can be of great help by having the original design conform in general to the requirement for good appearance. By giving the industrial designer the best possible preliminary design, the final result will not only be attained more quickly but will also be correspondingly better.

Lubrication of Sleeve Bearings—I

R.G.N. EVANS
Research Engineer
The Bunting Brass & Bronze Company

In this first of four articles to appear in consecutive issues, the author reviews the design requirements for proper lubrication. The next article will explain the correct design of an oil circulating system, as used in automobile engines

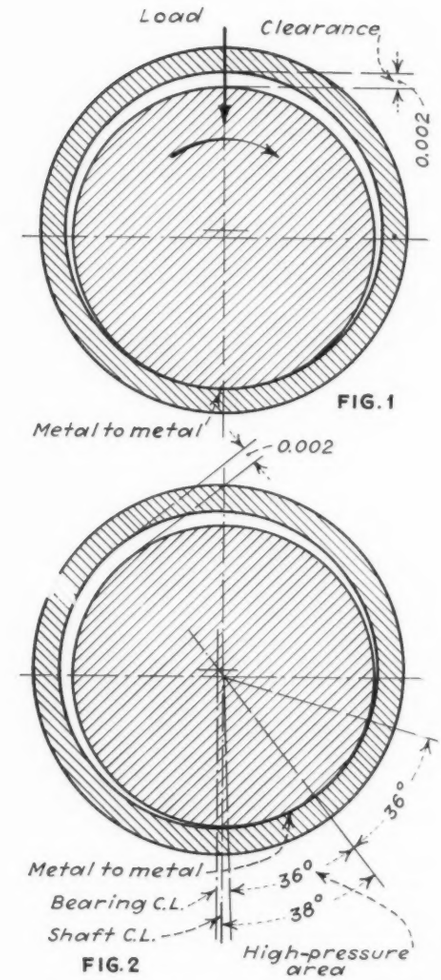


Fig. 1—Position of shaft at rest in its bearing. Fig. 2—Position of shaft immediately after rotation has begun

BEFORE any correct analysis of a problem in bearing lubrication can be made, the different variable factors must be established. Although it is not possible to list every conceivable condition that must be considered in making provisions for proper bearing lubrication, the following fundamental requirements or factors must be known in detail:

1. Magnitude and direction of load, speed and direction of rotation and the variable factors relative to both speed and load.
2. Conditions such as temperature and temperature range under which the bearing must operate, frequency of starting and stopping of the rotating shaft, and similar factors.
3. Shock loads to which the bearing might be subjected.
4. Precautions required to protect the bearing from outside elements such as acid fumes, dirt, water and other foreign matter.
5. Precautions required to protect the product of the machine, in the case of production machinery, from oil spillage. (In some instances protection must be afforded both against the entrance of foreign matter into the bearings and the spillage of oil out of the bearings.)
6. Available space for the bearing mounting together with the room available for applying oil seals.
7. Location of the bearing relative to its accessibility for visual inspection and lubrication by the operator or maintenance man.
8. Frequency of lubrication attention. In some instances the bearing must be designed so that no additional lubrication will be required during the expected life of the bearing.
9. Special conditions of operation that might require a special lubricant.
10. Position of the bearing, whether horizontal, vertical or inclined.
11. Magnitude and direction of thrust load to which the bearing or journal might be subjected.

All of the problems with reference to the size and location of the oil holes and the location and type of grooving must be analyzed by a study of the action of the journal running in its bearing. Although this action is quite generally understood, it will be briefly reviewed here in order to simplify the explanations of the requirements of lubrication.

In Fig. 1 is shown the position of a shaft at rest in its bearing. In Fig. 2 is shown the position of the shaft immediately after it has begun to rotate in a clockwise direction and before a lubricating film has been established between the journal and the bearing. The friction between the shaft and the bearing surfaces has compelled the shaft to climb the bearing wall as shown in the diagram. The amount of this movement will be affected by the magnitude of the applied load, the speed of the shaft, the surface finish on the journal and on the bearing, and the materials of the journal and the bearing.

It is evident that with no lubrication the continuous rotation of the journal would quickly score and ruin both shaft and bearing. But this condition of no lubrication is only momentary. If the bearing is properly designed, an oil film will be formed quickly between the journal and the bearing and scoring will not occur during the momentary rotation before the oil film has been established. Hence, when loads are high and speeds are low, or when the shaft comes up to speed at a slow rate of acceleration, there will be relatively

severe scoring action. With relatively light loads and quick acceleration, the scoring action will be correspondingly small. The general problem of lubrication is to provide the correct means of introducing the lubricant into the bearing so that the oil film will be established quickly and will be maintained. The first thing to determine is the point of oil entry.

In Fig. 3 is shown the position of a loaded journal in its bearing, the direction of rotation and the location of the high-pressure area being as indicated. The point of oil entry should be on the approach side of the high-pressure area. This will permit the journal to quickly carry the lubricant into the high-pressure region before the oil has had an opportunity to be squeezed out through the end of the bearing. Establishment of this oil film in the high-pressure area separates the bearing and journal surfaces and this movement causes the center line of the high-pressure area to move in the same direction as the shaft rotation. This movement of the high-pressure area will continue as the load increases or the slipperiness of the film of lubricant increases.

If the point of oil entry were at *B*, Fig. 3, it would be necessary for the journal to carry the lubricant through an angle of about 270 deg. of rotation before reaching the point where the oil film is to be established. Failure to establish the film would be made evident by the center line of the high-pressure area moving in a direction opposite to the direction of rotation of the journal. That is, continued contact between the journal and the bearing surface would cause the shaft to climb up higher on the wall of the bearing.

With a properly established oil film, the movement of the center line of the high-pressure area in the direction of the rotation of the shaft is quite appreciable as shown in Fig. 4. This figure illustrates the action of a 2-in. diameter chain-driven camshaft made of 1045 S.A.E. steel, hardened and ground, running at 2,000 r.p.m. under a load of 200 lb. As shown in the figure, the center line of the high-pressure area has moved through an angle of 23 deg. in the direction of the shaft rotation. Further travel of this high-pressure area is limited because it cannot cross the line of action of the load.

Movement of the lubricant when it is introduced on the side of the bearing opposite to the high-pressure area is illustrated in Fig. 5. The film of lubricant quickly spreads and in the low-pressure area of the bearing where the clearances are relatively large, it would tend to leak out at the ends. There would then be insufficient lubricant to properly form the film in the high-pressure area.

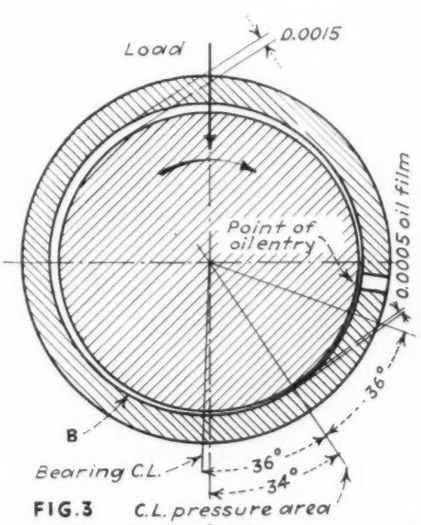


FIG. 3

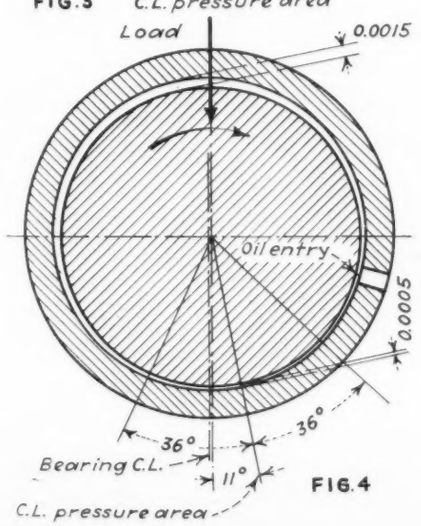
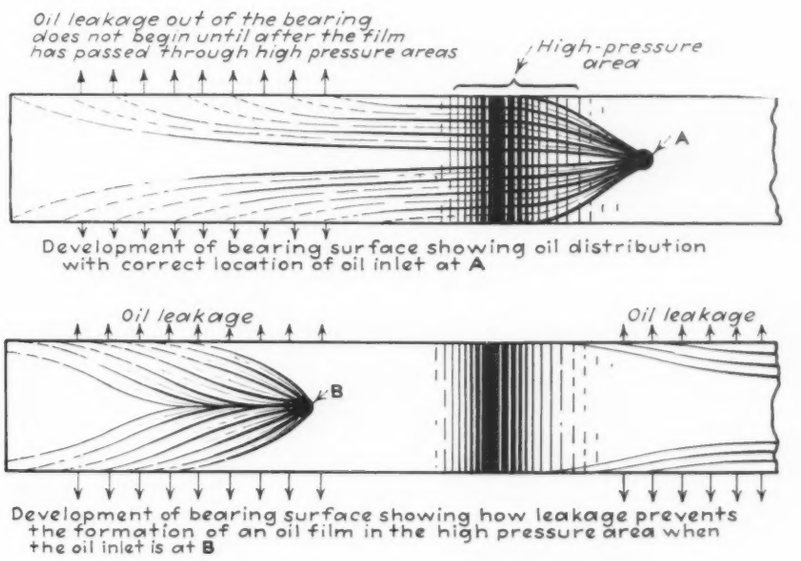


FIG. 4

Fig. 3—As rotation continues an oil film is established over an arc of about 72 deg. Fig. 4—The center line of the high-pressure area then moves in the direction of shaft rotation


Oil leakage out of the bearing does not begin until after the film has passed through high pressure areas
High-pressure area
A
Development of bearing surface showing oil distribution with correct location of oil inlet at A
Oil leakage
Oil leakage
B
Development of bearing surface showing how leakage prevents the formation of an oil film in the high pressure area when the oil inlet is at B

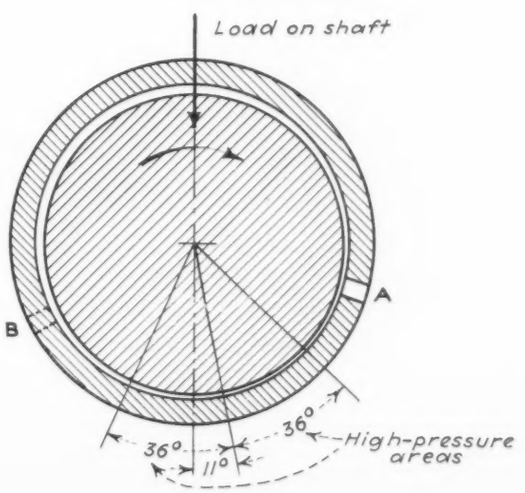
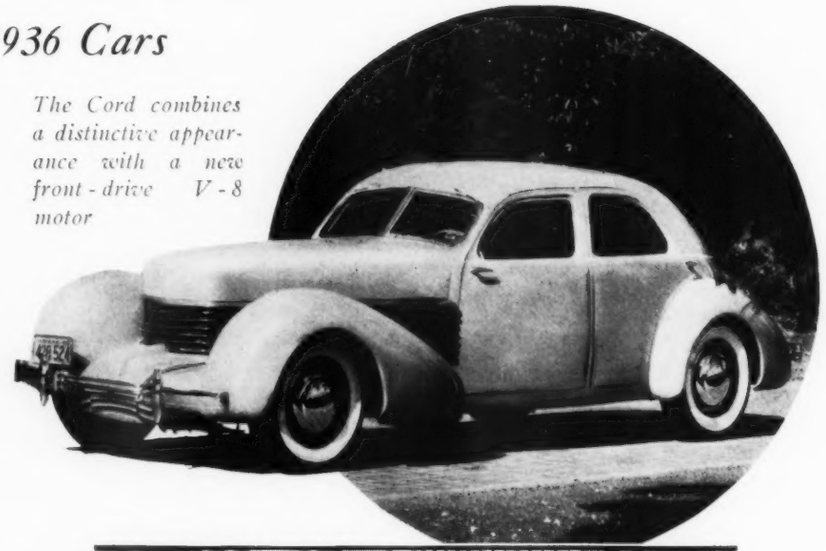


Fig. 5 (Right)—Illustrating why the oil inlet should be just ahead of the light-pressure area

PRODUCT DEVELOPMENTS

Design Changes in 1936 Cars



The Cord combines a distinctive appearance with a new front-drive V-8 motor

In the Lincoln Zephyr the body carries all structural loads since no frame is used. The V-12 motor closely resembles the Ford V-8

● Developments in automotive design are popularly appraised on the basis of change in appearance. On this basis, among the 54 models displayed only two—the Lincoln Zephyr and the front-drive Cord—can be considered entirely new designs this year.

Similar in principle to the design used on the Chrysler Air Flow models of two years ago, the Lincoln Zephyr is designed so that body sheets carry an appreciable structural load. Torsional rigidity is obtained entirely from the body; no separate chassis frame is used. Elimination of deep chassis side rails in this model made possible a body floor low enough so that there are no running boards. However, this has required a relatively high tunnel for the drive shaft. It is interesting to note that with relatively minor changes in the body, the power plant could be shifted to the rear, indicating that perhaps this possibility was in the minds of the designers.

Two recent developments—independent springing and remote-controlled gear shifting—were adopted in designing the new front-drive Cord. Elimination of the solid front axle and the adoption of a V-type motor made possible a short hood length. In outward appearance the Cord introduces a new style in design characterized by the absence of ornamental decoration.

While many models have gone in for more radiator gadgets, trick hood ventilating louvers, chromium trim and decorative grilles, several others show a trend toward greater simplicity. Studebaker in a new line styled by Helen Dryden has gone far in simplifying decoration.

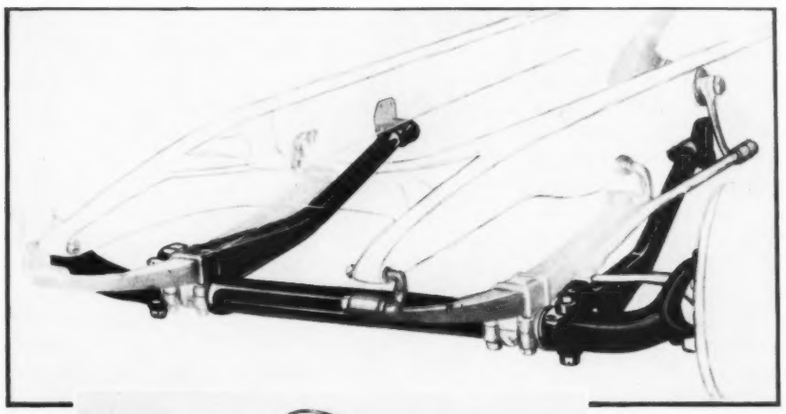
Relatively little change from last year has been made in spring suspensions or wheel mountings. The new Lincoln Zephyr, like the Ford, has transverse springs overhanging both front and rear. On the Cord a tranverse spring is used at the front, supporting wheels independently mounted on swinging arms that take driving thrust as well as braking torque applied to the front wheels.

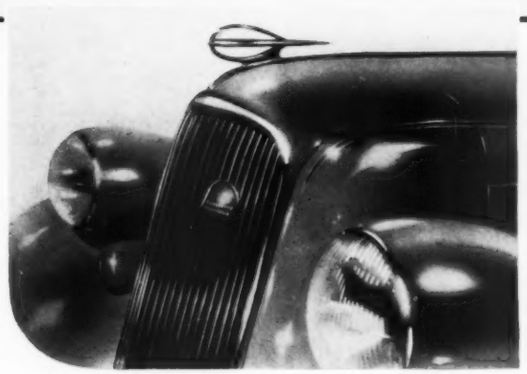
In the Hudson line, a radius rod for each end of a conventional front axle relieves the springs of braking torque. More flexible springs are used, with axle alignment and steering geometry controlled by the rigid radius arms.

Although changes in styling or appearance on the whole were not extensive, many detail design changes and improvements were made. In the bearing metals adopted for connecting rods, spun babbitt is still used in 20 models; 16 others have steel-backed babbitt of the interchangeable or removable type; 13 models, including all of the Chrysler line, have steel-backed copper-lead. Chromium-silver-copper alloy is still used on the three Pontiac models, but in each one copper-lead alloys are substituted in cars that are to be shipped to southwestern states. The copper-lead bearings are better able to resist attack from some types of lubricating oil common in that region.

Motor design rather than price class or size is apparently the controlling factor in selection of bearing materials. Among cars in the low-priced group, Ford uses separable babbitt in a large part of the production, Plymouth has steel-backed copper-lead, and Chevrolet and Terraplane use spun babbitt.

Main bearings are steel-backed babbit in 27 models including Ford and Chevrolet, while 17 models including most of the heavier cars use





Hudson and Terraplane front axles are held by drop-forged radius arms. (Left) Studebaker this year was styled by Helen Dryden who developed a design relatively free from ornamentation

bronze-backed babbitt. Steel-backed cadmium-silver bearings are used on 5 models. Dodge and De Soto have adopted copper-lead on cadmium-nickel for the two middle crankshaft bearings.

Piston material in 46 models this year is aluminum alloy, with 18 of them using anodic coatings to resist wear. Cast iron is still in use in 6 models, in each case tin plated to reduce wear. Ford has adopted a new type of alloy cast steel piston that weighs approximately the same as one of aluminum. This type of piston is also used in the V-12 Zephyr engine.

Aluminum alloy cylinder heads are being adopted rapidly, and are standard on 20 models this year. Other manufacturers offer an aluminum head as optional equipment in nearly every instance.

With the increased adoption of aluminum cylinder heads, compression ratios have been increased again. Compression ratios between 6.00 and 6.50 are now standard in 37 cars, and optional heads with ratios higher than 7.00 are offered.

For timing, 45 models have chain drive while 9 have fabric gears. As compared with last year this represents a small increase in the number of chain drives.

Valve seat inserts are now used in 13 models including all cars built by Chrysler and Ford. Composite exhaust valves with an austentic steel head welded to a stem of SAE 3140 has been adopted by Packard, Graham, Hupmobile, Nash and Studebaker.

Oil filters are standard on 28 models—all but Plymouth are cars in the higher price groups. Automatic chokes are designed into 30 models in the higher price brackets. Ventilated clutches are standard on 35 cars.

Fans in the Chrysler Airflow and Lincoln Zephyr are mounted on the crankshaft. In all other models a V-belt drive is used. The angle of V ranges from 46 deg. to as low as 28 deg. An angle between 40 and 45 deg. has been adopted for more than half the models.

• *Beryllium-Copper Dies for Plastic Samples*

Molds for plastic parts having surfaces or contours that are expensive to machine are now being made at low cost from cast beryllium-copper dies. This process is also being applied as a low-cost method of obtaining a limited number of sample parts even where final dies would be machined from steel.

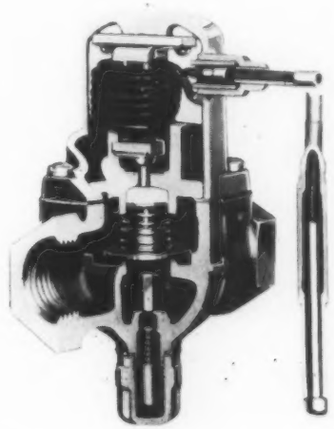
Wood or plaster models are made from preliminary drawings. These parts are used in making the beryllium-copper castings which are then heat-treated and used as molds for plastics. Since the beryllium-copper mold can be remelted with relatively little loss, the die cost for a sample quantity of plastic parts may be as low as 10 per cent of the cost of machined steel dies.

• *Thermoelectric Operation for Valves*

In thermocouple elements commonly used in temperature indicating and controlling instruments, the current generated is too small to operate relays or electromagnets. The current can be increased either by increasing the temperature difference between the hot and cold junctions, or by decreasing the electrical resistance of the circuit.

Both methods are used in the thermoelectric gas valve shown here made by the Milwaukee Gas Specialty Company. By using large copper conductors for the leads, and large cross-sections for the thermocouple, low resistance is obtained. The construction used for the thermocouple allows the hot junction to be placed directly in the gas flame. The entire couple is inclosed within a heat-resisting high-chrome steel tube which is also part of the circuit. The inner element is thus protected from the flame. A current of more than one ampere is delivered by the thermocouple, which operates a magnetic valve directly.

When used as a shut-off control for gas burners, the thermocouple is placed in the pilot flame. When the couple is heated the current in-



Thermoelectric current generated by heating the extended couple operates an electromagnet in the automatic shut-off valve

creases through the operating coil surrounding an armature of low permeability nickel iron, and the armature is lifted, opening the gas valve. If the pilot light goes out, the gas valve remains closed.

• *Light Weight Die-Castings*

For underwater parts of outboard motors, aluminum alloys have been extensively used to obtain light weight and corrosion resistance. In former models of the Johnson "Sea Horse" the aluminum alloy parts were sand cast or made in permanent molds. In the new model shown here, many of the castings have been replaced by aluminum-silicon alloy die-castings.

Because the die-castings have smooth surfaces and accurately held contours, manufacturing costs on these parts was reduced nearly one-half. In addition, closer tolerances and simplification in design made possible by die-casting resulted in appreciable reductions in assembly time, and contributed also to a reduction in weight.

Some of the larger die-cast parts, the rudder (1), rudder block (2), attaching clamp (3), and tube clamp (4), are shown in the accompanying illustration.

Other improvements incorporated in the new model include a new cooling system using both pressure and vacuum, and a carburetor permitting a six to one speed range.

• *Periodic Lubrication Eliminated*

Since business machines seldom get much attention as long as they continue to operate, bearings requiring frequent oiling are often neglected until excessive wear occurs. Elimination of the necessity for periodic lubrication has the further advantage of cleanliness. In addition to the class of operators who never oil a machine, there are those who overdo it. In the new rotary Ditto machine shown here the necessity for periodic attention to lubrication has been eliminated entirely by extensive use of sealed and oilless bearings. The only part requiring any attention, and then only twice a year, is a small speed reducer. All other bearings are lubricated for life.

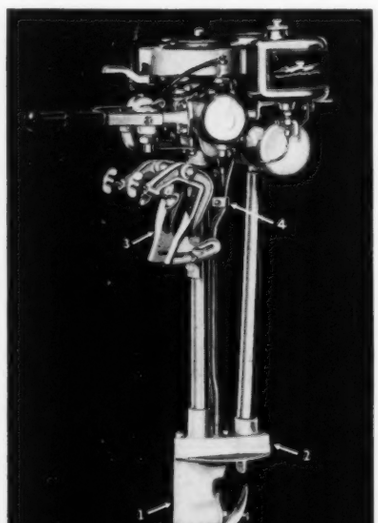
Other features incorporated in the machine include rubber cam rollers to eliminate noise and vibration. Cast aluminum is used for the rotating drum to obtain quicker starting and stopping. The drum is anodically treated. The operating mechanism is assembled in a die-cast frame which is a separate unit from the cabinet.

Complete operation is controlled by pedals, leaving the operator's hands free for feeding. Illumination is built in, controls are interlocked to prevent improper operation, and all the parts are cadmium plated or chromium plated to prevent corrosion.

• *Random Jottings*

Coca-Cola syrup is a highly volatile product and is affected by contact with most metals and alloys. For shipping syrup from the factory to distributors, 55-gal. drums are made of USS 18-8 stainless steel. The same material is used for tanks, sugar feeders and pipe lines in a recently constructed plant so that the syrup comes in contact with nothing but stainless steel.

Baseball bats made by A. G. Spalding & Bros. are processed with Temp-Urd-Wood. In this process the bats are impregnated with a synthetic resin and heat-treated.



Die-castings replace sand castings for aluminum alloy parts in the Johnson outboard motor, resulting in lower costs and easier assembly

(Below) Four aluminum-silicon alloy die-castings made by Dochler for the Johnson motor

Neglected lubrication will not affect the new rotary Ditto duplicator because sealed or oilless bearings are used throughout

Tolerances and Clearance Limits

F. J. POTTER
Timken Silent Automatic Company

How the limits of clearances can be established by expressed tolerances or can be fixed by limit gages

THE USUAL method of dimensioning the location of bolt holes when making engineering drawings is to give a bilateral tolerance (plus or minus tolerance) for such dimensions. The problem of determining these tolerances is simple when the holes are arranged in a straight line but becomes more complex for more than one row of holes and for holes spaced about a circle. When determining the relation between the tolerance to be allowed and the minimum clearance (minimum hole diameter minus maximum stud diameter), the following factors are to be considered: (*a*) Number of holes, (*b*) number of rows or circular spacing, (*c*) manner of attaching mating parts together if studs have loose fit in individual parts or if studs are rigidly fixed in one part, (*d*) importance of hole location from the edges (or equivalent) of the parts.

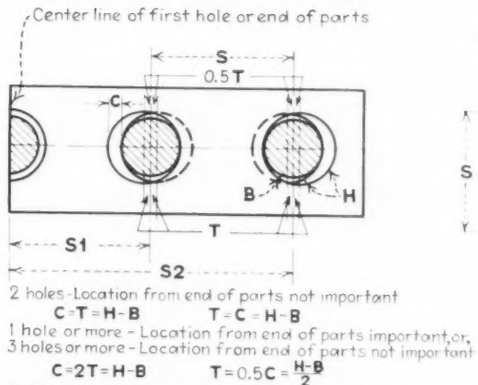
The tolerance allotted for the hole spacing dimension is determined by the relation of the minimum clearance and the number of holes and rows of holes. With studs having a loose fit in the individual parts, the entire minimum clearance is utilized for tolerance calculations when the parts are fastened together. One-half the minimum clearance is utilized for tolerance calculations when the studs are rigidly fixed in one of the parts.

Whether a group of holes be accurately located from the edge or from another hole, the method of establishing dimensional limits is the same. When the distances from the edges are important all the holes are dimensioned from these edges. If not important, one of the holes is selected and the locations of all the other holes are dimensioned from that hole. This type of dimensioning results in a minimum number of compound tolerances.

In the formulas for Figs. 1 to 6:

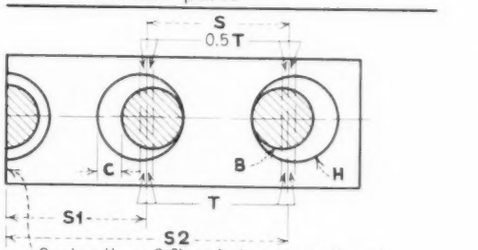
C = Minimum clearance
T = Tolerance (+ or —)
H = Minimum hole diameter
B = Maximum stud or bolt diameter
S = Spacing of holes or studs
R = Normal bolt circle radius

Each illustration shows a combination of conditions. In Figs. 1 and 2, the dimensioning above the center line represents two holes in parts and dimensioning below center line represents three holes (or



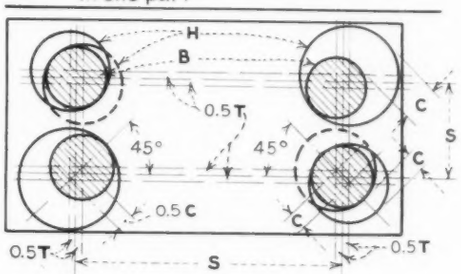
2 holes - Location from end of parts not important
$C = T = H - B$ $T = C = H - B$
1 hole or more - Location from end of parts important, or, 3 holes or more - Location from end of parts not important
$C = 2T = H - B$ $T = 0.5C = \frac{H-B}{2}$

FIG. 1 - Single row with studs loose fit in individual parts



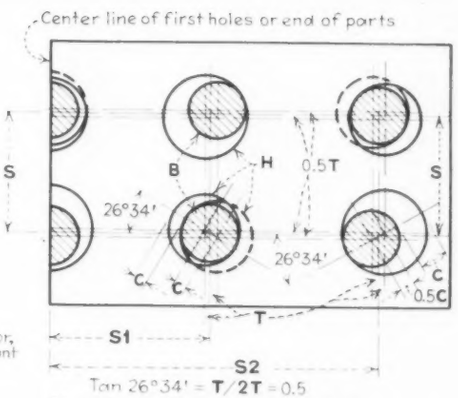
2 holes - Location from end of parts not important
$C = 2T = H - B$ $T = 0.5C = \frac{H-B}{2}$
1 hole or more - Location from end of parts important, or, 3 holes or more - Location from end of parts not important
$C = 4T = H - B$ $T = 0.25C = \frac{H-B}{4}$

FIG. 2 - Single row with studs rigidly fixed in one part



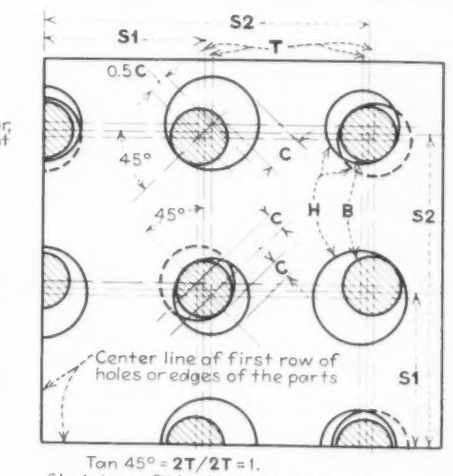
Studs loose fit in the individual parts
$C = H - B = \text{Cosec } 45° \times T$ $C = 1.4142T$
$T = \text{Sin } 45° \times C = 0.70711C$
Studs rigidly fixed in one part
$C = H - B = \text{Cosec } 45° \times 2T$ $C = 2.8284T$
$T = \text{Sin } 45° \times 0.5C = 0.35355C$

FIG. 3 - Double row - 4 holes - Location from the edges of the parts not important



Tan 26°34' = T/2T = 0.5
Studs loose fit in the individual parts
$C = H - B = \text{Cosec } 26°34' \times T$ $C = 2.23549T$
$T = \text{Sin } 26°34' \times C$ $T = 0.44724C$
Studs rigidly fixed in one part
$C = H - B = \text{Cosec } 26°34' \times 2T$ $C = 4.47098T$
$T = \text{Sin } 26°34' \times 0.5C$ $T = 0.22362C$

FIG. 4 - Double row - 6 holes or more - Location from edges of part not important.
Double row - 4 holes or more - Location from end of part important



Tan 45° = 2T/2T = 1.
Studs loose fit in the individual parts
$C = H - B = \text{Cosec } 45° \times 2T$ $C = 2.8284T$
$T = \text{Sin } 45° \times 0.5C = 0.35355C$
Studs rigidly fixed in one part
$C = H - B = \text{Cosec } 45° \times 4T$ $C = 5.6568T$
$T = \text{Sin } 45° \times 0.25C$ $T = 0.17678C$

FIG. 5 - 1 row or more - 1 hole or more - Location from edges of part important.
3 rows or more - 9 holes or more - Location from edges of part not important

their equivalent) in the parts. Both methods of attaching the parts, with studs loosely fitted or rigidly fixed, are shown in Figs. 3, 4, 5, and 6. Figs. 5 and 6 also represent more than one condition in the quantity and arrangement of the holes. The tolerances given must be such that parts made to the minimum dimensions will properly fit with mating parts that are made to the maximum dimensions. The illustrations show a part with minimum spacing of holes or studs mating with a part having maximum spacing of holes or studs. The value of tolerance T in terms of minimum clearance C or vice versa is determined to meet these conditions.

No criticism can be made of the tolerances determined for the spacing dimensions in a single row, whether the location from the end of the parts is important or not as in Figs. 1 and 2. For the other examples where compound tolerances are involved, the determined tolerances might be debatable as being too strict. It is also improbable that mating parts would both reach the extreme conditions in opposite directions.

In Table I are given the values for the tolerances T and the minimum clearance C in terms of each other, also their numerical values when 0.010 in. and 0.031 in. are assigned T and C respectively. The minimum value for the normal bolt circle radius R is given in terms of T and numerically when 0.010 in. is assigned as the value of T. The 0.010 in. value of T is the usual tolerance allowed for fractional dimensions and a drill $\frac{1}{32}$ in. larger than the maximum stud diameter is usually selected for the clearance holes.

There are several ways of dimensioning hole locations on bolt circles. The method shown in Fig. 6 is to specify the radius with an expressed tolerance and to designate the number of holes with a note, also that the holes must be equally spaced within the tolerance selected for the radius.

Derivation of the formulas for T and C becomes complex for holes on bolt circles, Fig. 6, when the highest possible degree of accuracy is desired. Reasonable accuracy for the values of T and C can be obtained from the formulas given in Table II, the derivation of the formulas being comparatively simple. The value of the angles, which vary with each individual problem, are taken as shown, to keep the triangles involved as right angle triangles, thereby simplifying the calculations. The discrepancy in the angle opposite B is ignored.

Earle Buckingham suggests a method of dimensioning the locations of bolt holes without expressed tolerances in his book, "Principles of Interchangeable Manufacturing." By this system a flat or exact decimal dimension is used for the hole spacing measurement and the variation permissible is given by specifying the size of the gaging pin or gaging hole.

In Fig. 7 is shown the relation between the gage and a part having a combination of both methods of fastening parts together. With the flat or exact method of dimensioning, exact dimensions for locating the holes or studs from the edges of the part are used when the location is important. In Fig. 7, C = minimum clearance; H = minimum hole; B = maximum bolt; Gp = gaging pin; Gh = gaging hole; D = circle of eccentricity.

The reason for such dimensioning is that a gage having pins or holes of the size specified and spaced according to required dimensions shall check the part. By this method the holes can be eccentric in any direction to the points dimensioned, the radius of eccentricity increasing with an increase in hole size.

TABLE I—VALUES OF T AND C

Fit of Studs in Parts				Studs Loose Fit in Both Parts			Studs Rigidly Fixed in One Part		
Rows	No. of Holes	Location from Edges	Radius Toler.	Fig. No.	Value T in in. $C = 0.031$	Value C in in. $T = 0.010$	Fig. No.	Value T in in. $C = 0.031$	Value C in in. $T = 0.010$
Single	2	Not important		1	C or 0.031	T or 0.010	2	$0.5C$ or 0.015	$2T$ or 0.020
Single	1 or more	Important from end		1	$0.5C$ or 0.015	$2T$ or 0.020	2	$0.25C$ or 0.007	$4T$ or 0.040
Single	3 or more	Not important		1	$0.5C$ or 0.015	$2T$ or 0.020	2	$0.25C$ or 0.007	$4T$ or 0.040
Double	4	Not important		3	$0.7C$ or 0.021	$1.4T$ or 0.014	3	$0.35C$ or 0.011	$2.8T$ or 0.028
Double	6 or more	Not important		4	$0.45C$ or 0.014	$2.2T$ or 0.022	4	$0.22C$ or 0.007	$4.5T$ or 0.045
Single or more	1 or more	Important		5	$0.35C$ or 0.011	$2.8T$ or 0.028	5	$0.18C$ or 0.0056	$5.7T$ or 0.057
Triple or more	9 or more	Not important		5	$0.35C$ or 0.011	$2.8T$ or 0.028	5	$0.18C$ or 0.0056	$5.7T$ or 0.057
Holes on bolt circle	3	Holes equally spaced within $\pm T$	$58T$ 0.58	6	$0.35C$ or 0.011	$2.8T$ or 0.028	6	$0.18C$ or 0.0056	$5.7T$ or 0.057
	4		$42T$ 0.42		$0.4C$ or 0.0120	$2.45T$ or 0.0245		$0.2C$ or 0.0060	$4.9T$ or 0.049
	6		$34T$ 0.34		$0.43C$ or 0.0130	$2.3T$ or 0.023		$0.22C$ or 0.0060	$4.6T$ or 0.046
	8		$32T$ 0.32		$0.44C$ or 0.014	$2.16T$ or 0.0216		$0.22C$ or 0.007	$4.3T$ or 0.043
	10	Radius $\pm T$	$31T$ 0.31		$0.44C$ or 0.014	$2.25T$ or 0.0256		$0.22C$ or 0.007	$4.5T$ or 0.045
	12		$31T$ 0.31		$0.44C$ or 0.014	$2.25T$ or 0.025		$0.22C$ or 0.007	$4.5T$ or 0.045

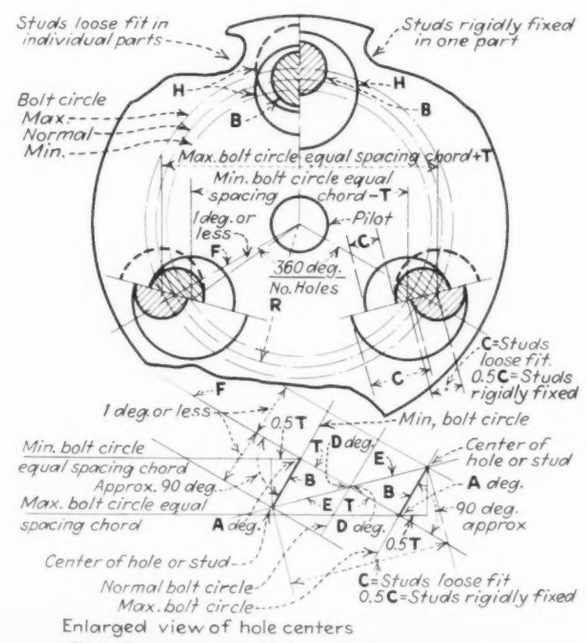


FIG. 6—Holes on bolt circles—Equally spaced within $\pm T$ with radius $\pm T$

TABLE II—DIMENSIONING HOLE LOCATIONS ON BOLT CIRCLES

Formula for any number of holes	3 Holes	4 Holes	6 Holes	8 Holes	10 Holes	12 Holes
A = Approx $\frac{360 \text{ deg.}}{2 \times \text{No. Holes}}$	60 deg.	45 deg.	30 deg.	22½ deg.	18 deg.	15 deg.
Secant A deg.	2.0000	1.4142	1.1548	1.0824	1.0515	1.0353
$B = 0.5T \times$ Secant A deg.	T	$0.70711T$	$0.57734T$	$0.54120T$	$0.52575T$	$0.51765T$
Tan D deg. $= B/T$	1.0000	0.70711	0.57734	0.54120	0.52575	0.51765
Angle D deg.	45 deg.	35 deg.–16 sec.	30 deg.	28 deg.–25 sec.	27 deg.–44 sec.	27 deg.–22 sec.
Secant D deg.	1.4142	1.2248	1.1547	1.0824	1.1298	1.1260
Cosine D deg.	0.70711	0.91648	0.86602	0.87951	0.88512	0.88808
E = Sec D deg. $\times T$	$1.4142T$	$1.2248T$	$1.1547T$	$1.0824T$	$1.1298T$	$1.1260T$
With Studs Loose Fit in the Individual Parts						
$C = 2E$ = Sec D deg. $\times 2T$	$2.8284T$	$2.4496T$	$2.3094T$	$2.1684T$	$2.2596T$	$2.2520T$
With Studs Rigidly Fixed in one Part						
$C = 4E$ = Sec D deg. $\times 4T$	$5.6568T$	$4.8992T$	$4.6188T$	$4.3296T$	$4.5192T$	$4.5040T$
With Studs Loose Fit in the Individual Parts						
$T = 0.5C \times$ Cos D deg	$0.35355C$	$0.40824C$	$0.43301C$	$0.43976C$	$0.44256C$	$0.44404C$
With Studs Rigidly Fixed in one Part						
$T = 0.25C \times$ Cos D deg	$0.17677C$	$0.20412C$	$0.21650C$	$0.21988C$	$0.22128C$	$0.22202C$
Cot 1 deg. $= 57.29$ $F + T =$ Cot 1 deg. $\times B + T$	$58.25T$	$41.5T$	$34.0T$	$32.0T$	$31.125T$	$30.75T$

The method of fastening parts together is the only factor to be considered when determining the relationship between the specified size of the gaging pin or hole and the minimum clearance. If the studs have a loose fit in the individual parts, the diameter of the gaging pins is the same size as the maximum diameter of the studs. Holes of minimum diameter in such parts will be eccentric to the points dimensioned, an amount equal to one-half the minimum clearance. If the studs are rigidly fastened in one of the parts, the gage can invade the minimum clearance not over 50 per cent. Therefore, the size of the gaging pins or holes must be of a diameter equal to the maximum stud diameter plus one-half the minimum clearance. This will allow the minimum diameter holes of a part or the studs of a mating part to be eccentric with the points dimensioned, an amount equal to one-quarter the minimum clearance.

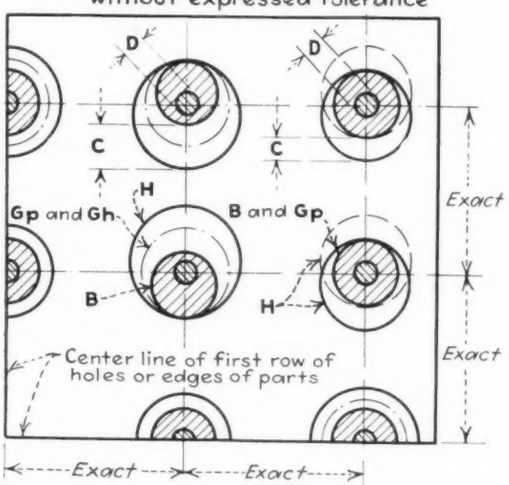
When comparing the two methods of dimensioning bolt hole locations, several factors are to be considered. When determining tolerances, the work of the draftsman is somewhat complicated, compared to the simple problem of determining the gaging hole or gaging pin sizes. The use of a chart, with the values for the tolerance and the minimum clearance given, as in Table I, simplifies the task.

The eccentricity of the holes to the points dimensioned without expressed tolerances is contained in a circle when the hole locations are given. The eccentricity of the holes to the mean dimensioned points with expressed tolerances is usually contained in a rectangular area as in Fig. 8. As the rectangular shaded area lies within the corresponding circle of eccentricity, expressed tolerances restrict the amount of variation in the hole locations.

The system of expressed tolerances for bolt hole location dimensions makes possible inspection with measuring instruments possible, but gages also can be used. If a gage is used to check the dimensions, the parts should be checked with gages equivalent to those made for pieces where the tolerance is not directly expressed. Although such gages would not check the dimensions given, they would allow the parts to vary more than the tolerances allowed under certain conditions. The gages can also check the coinciding features of mating parts.

The system of locating holes without expressed tolerances allows parts to be checked with a gage. Although gages are to be preferred for checking the parts, the drawing should supply enough data to allow the checking to be done with measuring tools. It is necessary to check each hole or stud in relation to all the other holes or studs in the part. When a large number of holes or studs are involved, the unexpressed tolerance method makes this checking impractical.

FIG. 7—Dimensioning the location of holes without expressed tolerance



Studs loose fit in the individual parts
Gp = B = H − C D = H − Gp = C
Studs rigidly fixed in one part
Gp and Gh = B + C/2 = H − C/2
D = H − Gp = Gh − B = C/2 C = H − B

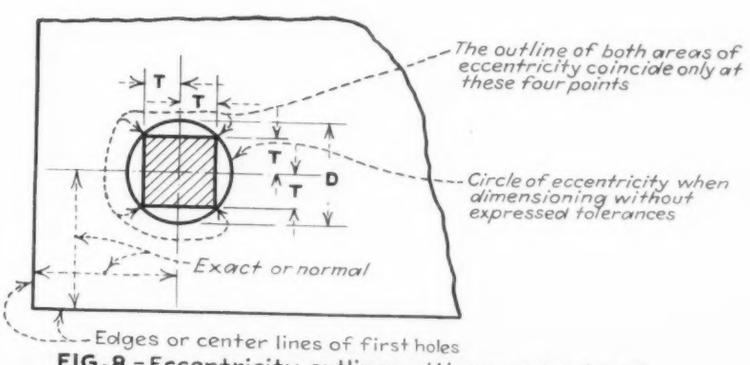

The outline of both areas of eccentricity coincide only at these four points
T
T
T
T
D
Circle of eccentricity when dimensioning without expressed tolerances
Exact or normal
Edges or center lines of first holes

FIG. 8—Eccentricity outlines with expressed and unexpressed tolerance

BEARING METALS for Severe Service—II

PRESENT trends to increased performance in the design of airplane and automotive engines, high-speed diesels and heavy machinery are bringing up many bearing problems. For normal bearing service standard bronzes and babbitts are satisfactory, but for more severe service the new bearing alloys have distinct advantages.

Although no one bearing material is best for all applications, each of the alloys have outstanding properties as well as definite limitations. In the first installment of this symposium appearing on page 362 in the October number, bearing requirements in automotive engines were outlined. Contributions from engineers of three bearing alloy manufacturers described the composition, structure and properties of copper-lead, cadmium-silver-copper, and cadmium-nickel bearing alloys. In this concluding installment, more materials are described.

Fig. 3—Microsection of Satco at 100 diameters showing dispersed hard particles of calcium-lead compound

▼ ▼ ▼

Lead-Alkali Bearing Metal

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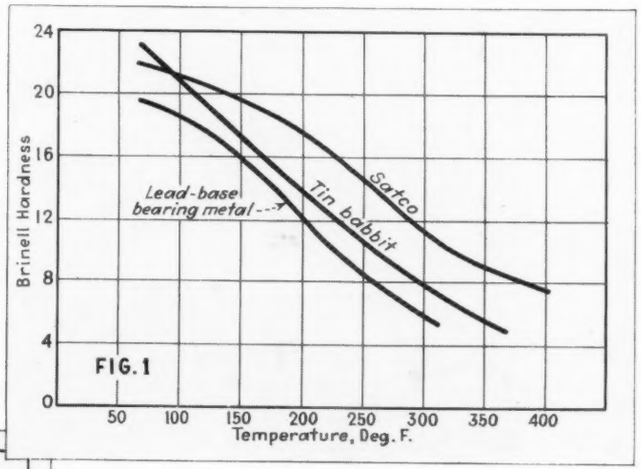
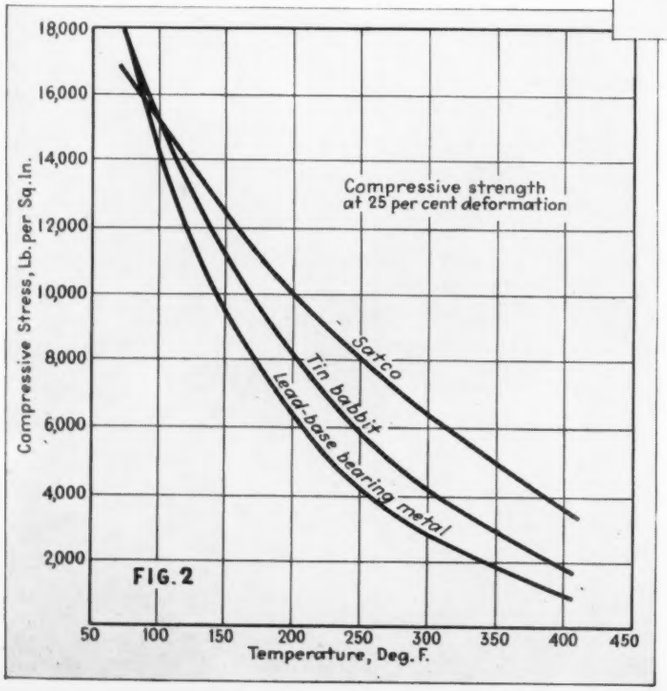
Research Laboratories
National Lead Company





Figs. 1 and 2—Brinell hardness and compressive strength of three types of bearing metals at elevated temperatures

WHILE several bearing metals of the type designated as lead-alkali and lead-alkaline-earth metals have been developed recently in Germany to withstand more severe service, the only type that has been extensively applied in this country is Satco. The structure of this bearing metal, as shown in Fig. 3, consists of a network of calcium lead compound ($CaPb_3$) dispersed throughout a ground mass of lead containing tin and calcium in solid solution. In addition to having good frictional properties, this material is less affected by temperature than babbitt alloys.

From the hardness curve shown in Fig. 1, this lead-alkali bearing metal still retains a fair amount of its room temperature hard-

ness at 400 deg. F., a temperature which may be reached in gas engines. At this temperature, in both the tin-babbitt and the lead-base alloy the hard constituents in the bearing metal will be forced into the softened matrix. In the lead-alkali metal, the matrix will still support the hard particles.

As shown by the data in Table I, Satco metal starts to melt at temperatures more than 100 deg. F. above that of two standard alloys. Safe operating temperatures for the lead-alkali metal are so high that the lubricating oil may smoke and thus give a warning signal that the bearing is not functioning properly before the bearing metal melts out.

Alloys wipe at temperatures close to the melting point of their most easily fusible constituents. The wiping temperature of tin-base babbitt is about 320 deg. F. while a temperature of 520 to 550 deg. F. is required for Satco metal.

The bonding strength of this alloy has been determined by casting $\frac{1}{4}$ in. of metal between the previously tinned ends of 0.8 in. diameter metal rods. The strength of the butt joints was determined by pulling the specimens in a testing machine, with the results shown in Table II. No dovetail grooves or other mechanical means of anchorage were used.

Compressive strength data for all three bearing alloys are shown in Fig. 2 for 25 per cent deformation. The higher the temperature the greater the percentage difference is shown in favor of Satco. At 400 deg. F. the lead-alkali metal has approximately twice the compressive strength of babbitt metal. Under heavy loads found in crankshaft bearings in modern railway diesel engine, this characteristic of Satco has led to its adoption in such trains as the New Haven "Comet," the Burlington "Zephyr," the Union Pacific *M-10001*, and the Boston and Maine "Flying Yankee."

The trend in designing bearings is to use thinner linings, particularly in automobile engines where linings as thin as 0.03 in. are being used. Diminishing the thickness of the bearing metal linings considerably prolongs the life of the bearing since a thin lining is subjected to less bending stress. Also a thin plate of soft material between two hard bodies has a greater flow resistance than a thicker plate of the same material.

TABLE 1—Characteristics of Three Bearing Alloys

	Temperatures in deg. F.		
	SAE 13 Lead-Base Babbitt	SAE 11 Tin Babbitt	Satco Bearing Alloy
Mold temperature	190	180	225
Solidus temperature	462	460	563
Liquidus temperature	500	684	788
Casting temperature	660	800	1025

TABLE II—Tensile Strength of Bond with Lead-Alkali Bearing Alloy

	Tensile strength, lb. per sq. in.	
Bonding Surface	Fine finish	Rough finish
steel	8,250	8,020
manganese-bronze	7,720	8,750
10 per cent aluminum-bronze (copper plated)	8,250	10,180

▼ ▼ ▼

Graphited Bronze Bearings

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Federal Bronze Products Company

ONE recognized limitation in graphited bearings has been the effect of heat on the binder that holds the graphite in the bronze bushing. Extensive research during the past four years has resulted in the development of a binder material unaffected by any temperature that the bronze itself will withstand. These graphited bushings therefore meet the design conditions of high speed and heavy loads used for plain bronze bearings, and at the same time eliminate the problem of oil or grease lubrication for speeds of 2,000 to 3,000 r.p.m., or lower.

In combination with the improved binder, a new form of groove has added greatly to the lubricating effect of the graphite. As shown in Fig. 1, the bearing surface is divided into diamond-shaped areas by grooves filled with graphite. The grooves, occupying about 25 per cent of the total bearing area, are machined into the inner surface of the bushing, extending within $\frac{1}{16}$ in. from each end.

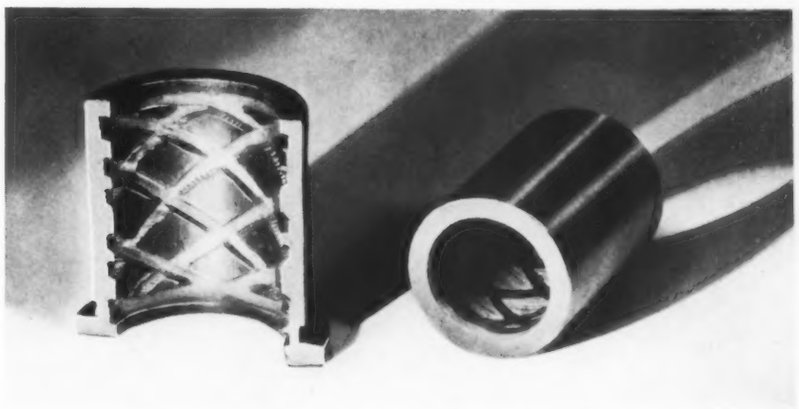

Fig. 1—In the Federal bearing a graphite mixture is pressed into machined grooves and baked

Under actual service as well as laboratory test conditions, these graphited bearings show even less wear than many types of oil-lubricated bearings. In a comparative test an oil-cup lubricated bearing showed five times as much wear as the non-lubricated graphited bushing, as shown in Fig. 2. The temperature of the plain bronze bearing was 32 deg. F. higher than that of the graphited bearing.

Since the graphite in the grooves spreads a film over the bronze surfaces, the bearing friction is as much as

25 per cent less than the friction in regular bronze bearings. The thickness of the graphite film being much less than the clearance required for an oil film, this type of bearing can have closer tolerances.

Since the binder and the graphite lubricant are unaffected by steam, water, gasoline or oils the graphited bearings can be used in any service which does not affect the bronze. Gasoline pumps, bottling and can-filling machinery, chemical pumps, and food or chemical mixers are operating with graphited bearings designed for the same loads and speeds that would be permitted with well lubricated bronze bearings.

Because the bearing needs no lubrication it is also being applied to airplane control pulleys, spring shackles on buses and trucks, tread pins in caterpillar-type tractors, and boom bearings in concrete mixers.

Under conditions of high temperature, graphited bearings retain their lubricant, reducing wear in such applications as furnace conveyor rollers and electric furnace bearings. In centrifugal separators used in the sugar industry the chemically resistant graphite provides lubrication during starting as well as at high speeds.

Where resistance to certain chemicals is required materials other than bronze are being used for the bushing. In order to save weight, graphited aluminum bushings are being used in one application. Since both the shaft and the bearing surface quickly become coated with a thin film of graphite, other alloys than bronze give good bearing performance.

Fig. 2—Comparative wear on a dry graphited bearing and an oil-lubricated bushing, both supporting the same load on a common shaft

In any type of graphited bearing the graphite must be permanently retained in the bushing. Since the graphite alone has little strength, a binder must be used to hold the graphite mixture in the grooves. This mixture in plastic form is forced into the grooves under high hydraulic pressure and the bushing then is baked. After this heat-treatment the graphite composition becomes an integral part of the bearing. In addition to hardening the graphite mixture, the binder material also has some lubricating value which improves the performance of the bearing at elevated temperatures.

Bronze Bearing Alloys

MANY developments that have taken place during the last several years in new bearing materials have been more with regard to improved processes of production than with new alloys. However, one of the new materials developed is a nickel-bronze having a low thermal expansion. As compared with most bearing metals, this alloy expands only a small amount with an increase in operating temperature. Yet, it has a load capacity in excess of that of many other bearing metals. According to N. K. B. Patch of the Lumen Bearing Company, this alloy machines readily and also holds its strength well at elevated temperatures.

The nickel bronze bearing has high resistance to wear, but because of this property the bearing requires accurate tooling and operates best with hardened and ground journals.

ANOTHER nickel-bronze alloy developed by the A. W. Cadman Manufacturing Company is reported to have the following properties:

Tensile strength	55,000 lb. per sq.in.
Yield point	48,000 lb. per sq.in.
Elongation in 2 in.	6 to 8 per cent
Brinell hardness	80 to 100

In compression, the yield point of this alloy is given as 24,000 to 25,000 lb. per sq.in. Therefore, a bearing pressure as high as 4,000 lb. per sq.in. still allows a factor of safety greater than five.

The alloy was developed for applications such as rolling mill machinery subjected to extreme load pressures and slow speeds. However, the maximum load speeds are dependent on the proper selection and application of the lubricant.

BECAUSE of its high hardness and resistance to wear after heat-treatment, beryllium copper is also reported to be finding applications as a bearing alloy. According to L. L. Stott of the Beryllium Products Corporation, no large-scale applications have yet been made, but several designers are testing the alloy. One engineer reports that a heat-treated beryllium copper bushing has successfully withstood tests under a unit bearing load of 14,000 lb. per sq.in. The steel shaft hardened to Rockwell C-58 rotated at a speed of 8,000 r.p.m. No other bearing alloy tested withstood this high load.

ACCORDING to E. M. Staples of Aluminum Industries, "Although we have not developed any new materials recently, we have contributed by making available all standard bronzes in 6-ft. lengths. With standard bearing bronzes available in rod form, many parts formerly made of yellow brass can now be made economically of bearing bronze on screw machines or turret lathes."

POWDERED bronze bearings are being applied to a number of designs in which it is desired that no lubrication attention be required. Such bearings are made by compressing and heat-treating powdered bronze. The porous bushing is then saturated with oil. When in service, the oil is fed by capillary action.

The use of the powdered metal process of forming bearing metals is now being rapidly extended to other materials. Preliminary reports from laboratories disclose that powdered metals can be prepared with mixtures and compositions not possible with cast metals.

Charts Simplified
By Using Distorted Coordinates

An explanation of methods for constructing straight-line charts of equations that are normally represented by curves. Typical examples are given of their application

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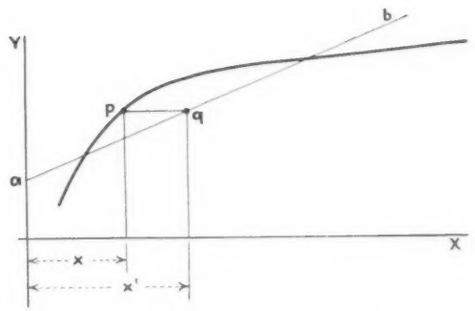


Fig. 1—Any equation can be represented by a straight line by distorting the coordinates

RELATIONS between two variables may be expressed by two methods: An algebraic equation or a curve using Cartesian coordinates. When there are three variables in the equation, then a curve may be represented by two of the variables, with the third assumed constant. By assigning another value to the third variable, a second curve may be drawn, and so on, with as many curves as there are values assigned to the third variable. Such a family of curves is difficult to construct with the curves close together and the interpolation between them is likely to be inaccurate. It would be much more convenient if these curves could be represented by straight lines.

If the equation is of the first degree, that is, if no term contains more than one variable having an exponent of 1, then the curve will always be a straight line. But, if the equation has more than one variable in any term, or one variable with an exponent higher than one, then the equation will be a curve. The typical equation for any straight line is,

$$y = ax + b$$

In this equation the term b is the intercept on the Y-axis and a, the coefficient of x, is the tangent of the angle that the line makes with the X-axis. If a family of curves is made from $y = ax + b$ by drawing a curve of simultaneous values of x and y for each successive value of a, with b constant, these will be straight lines or rays passing through a common point. For values of b, with a constant, these lines will be parallel.

By the method of anamorphosis, or distorting the coordinates, any curve can be represented by a straight line. For example, a curve such as the one shown in Fig. 1 can be represented by the straight line ab. The point p in the curve, with abscissa x, is moved horizontally to q on the line so that its new abscissa is x'.

When every point on the curve has been so transferred to the line, the curve will be represented by the straight line referred to the new coordinates.

The equation of a proportional scale along the Y axis, is $y = ma$, where a is the variable and m is the scale factor or modulus—the linear unit adopted on the drawing. It is evident, however, that a could represent any function of a, that is, any algebraic term comprising a with constants but with no other variable in the term.

For the purpose of showing this anamorphosis, take the hydraulics equation,

$$q = 6.3\, d^2\sqrt{h} \qquad (1)$$

In this relation q is quantity of water in cu.ft. per sec. flowing through a pipe of diameter d in ft. under a hydraulic head of h ft. If m is the modulus for for the q-scale along the Y-axis, then

$$y = m_1 q \qquad (2)$$

With m_2 the modulus of h along the X-axis,

$$x = m_2\sqrt{h} \qquad (3)$$

$$\sqrt{h} = x/m_2 \qquad (4)$$

By substituting q from Equation (1) and h from Equation (4), y can be expressed,

$$y = \frac{m_1}{m_2} 6.3\, d^2 x \qquad (5)$$

If the maximum value of h is 10, for a length of about 6 on the h-scale, then $x = 6$ when $h = 10$. Substituting these values in Equation (3), m is approximately 2 and the h-scale is $x = 2\sqrt{h}$. Taking 3 ft. as the maximum for d, with 10 for h, the maximum value for q is 179. Assuming this scale about 6 in. long, then $y = 6$ when $q = 179$. Substituting these values in Equation (2), m_1 is 1/30 nearly, and the q-scale is $y = \sqrt{q}/30$. Substituting this value of y in Equation (5),

$$y = 0.195\, d^2 x \qquad (6)$$

Assuming $d = 1$ for the first ray, then $y = 0.105x$. This is the equation of a straight line passing through the origin, with the line making an angle whose tangent with the horizontal is 0.105. After drawing the X and Y axes 6 units in length as shown in Fig. 2, each axis is graduated to scales given above.

From the origin along the X-axis a distance of 10 convenient units is marked off and 1.05 of the same

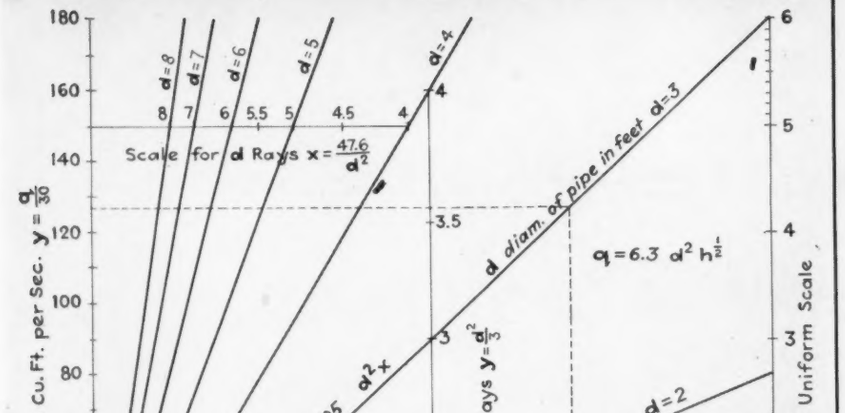


FIG. 2

Fig. 2—Straight-line chart of hydraulic equations containing three variables, with the formulas for the scale graduations shown on each axis

units used for the perpendicular axis. The ray through this point and the origin gives all values of h and q for $d = 1$. Similarly, for $d = 2$, the perpendicular is 2×1.05; and so on for each ray. The rays may be more quickly determined by making each vertical unit 1 instead of 1.05; and the rays are erected at $1/1.05 \times 10$ or 9.53, instead of at 10 units.

In this example the rays up to $d = 3$ fill but half the chart, and therefore additional rays are drawn in. But after the ray for $d = 4$, the scale becomes longer than the chart and the intersections become acute, tending toward inaccuracy. Therefore, a second d scale, at right angles to the first, is constructed for values of $d = 4$ and higher so that no intersection is sharper than 45 deg. The new scale is calculated by solving Equation (6) for x giving the relation,

$$x = \frac{y}{0.105d^2}$$

For $d = 4$, the value of x is $0.595y$. Then 10 units are laid off vertically from zero and 5.95 units perpendicularly, and so on, using the same perpendicular for each ray.

If the y-scale for the rays is erected at $x = 0.315$, by substituting this value in the ray equation $y = 0.105d^2x$ the scale equation becomes $y = d^2/3$. Similarly if the x-scale for the rays is erected at $y = 5$, the relation for the scale equation becomes,

$$x = \frac{47.6}{d^2} \qquad (7)$$

The extra rays drawn in will not give the higher values of h. The dotted index lines show, for a pipe diameter of 3 feet and a head of 5 feet, that 127 cu.ft. per second will be discharged.

Anyone of the three variables can be used for the X-axis. In Fig. 3, d is taken along the X-axis instead of h. The equations are $y = m_1q$ and $x = m_2d^2$.

Therefore the equation for the ray is,

$$y = \frac{m_1}{m_2} 6.3\, h^{\frac{1}{2}}x$$

For $m_1 = 1/30$ and $m_2 = 2/3$, then $y = 0.315h^{\frac{1}{2}}x$. One scale for h rays is sufficient. Additional h rays have been drawn in.

By the same procedure, as shown in Fig. 4, Equation (1) can be charted with x along the X-axis. Equation (1) solved for d gives $d^2 = q/6.3h^{\frac{1}{2}}$. The scale equations are $y = m_1d^2$, and $x = m_2/h^{\frac{1}{2}}$. Therefore,

$$y = \frac{m_1}{m_2}\frac{q}{6.3}x$$

For $m_1 = 2/3$, and $m_2 = 6$, the value for y is,

$$y = \frac{q}{56.7}x = 0.01765qx \qquad (8)$$

As an alternative to placing the scales for the q rays parallel to the axes, for convenience a 45-deg. line can be drawn 6 units from the origin and marked off as a scale. The ray intersections will always be greater than 45 deg. on this line. The equation of the line is $y = 6 - x$, and for a ray is $y = 0.01765qx$. When these simultaneous equations are solved for x and y, designating the distance from the upper end of the oblique scale to the d ray as L, the equation of the oblique scale is,

$$L = \frac{a\sqrt{2}}{bq + 1}$$

In this equation a is the side of the triangle and bq the coefficient of x in Equation (8) for the ray.

Figs. 2, 3 and 4 therefore illustrate the three ways of plotting Equation (1) according to the principles of anamorphosis. In drawing up working charts the scales are chosen so as to make square figures of approximately 6 in. on a side. The same problem is shown solved on each of the charts by the dotted index lines. A scale with uniform graduations is reproduced at the right of each of the figures so that the values of x and y may be checked, whatever the scale of the reproduction may be. Graduations should be sufficiently close that proportional interpolation will not introduce errors greater than other graphical errors. Charts of this type may be represented with only a few of the rays drawn. With a plainly marked scale on the figure, as many rays as may be needed can be readily drawn on the chart.

When there are four variables in the equation to be represented, the four variables may be reduced to three by introducing an auxiliary variable q equal to any two of the variables. In terms of the force P in lb. required to compress a spring F in. per turn, where d is the wire diameter and D the mean diameter of the spring coil, the helical spring formula is,

$$F = PD^3/kd^4$$

For a steel spring the constant k is $G/8$ or 1.44×10^6. To reduce the number of variables to three, let q equal PD^3. Then $q = kFd^4$. These two equations for q are plotted as two charts having the ordinate q in common. The common ordinate must therefore have the same scale equation in both charts although it need not be graduated.

For the first equation, $q = PD^3$, shown at the left in Fig. 5, the coordinate scales are $x = P/20$ and $y = q/100$. The equation of the ray is $y = D^3x/5$. The equation of the ray scale on Y, if erected at $x = 2.5$, is $y = D^3/2$, which has been used from $D = 1.9$ to $D = 2.5$; and if erected at $x = 5$, is $y = D^3$, which has been used from $D = 1.9$ down.

For the second equation, shown on the right of the chart, $q = 1.44 \times 10^6 Fd^4$, the coordinate scales are $x = 20F$, $y = q/100$, and the equation of the ray is $y = 720d^4x$. The equation of the ray scale on Y, if erected at $x = 3.47$, is $y = 2{,}500d^4$, which has been used from $d = 0.23$, down, and if erected at $x = 1.74$, is $y = 1{,}250d^4$, which has been used from $d = 0.23$ to 0.28. The dotted index lines show that for a spring with $F = 0.15$, $d = 0.19$, and $D = 1.9$ the force P is 41 lb.

For compactness the left chart can be moved to the right and superposed over the right chart, with the abscissas for the left chart placed above. This change has been made in Fig. 6, with all constructional data omitted and all the rays drawn in. The index lines show that a spring of 0.20 in. wire wound to a mean spring diameter of 1.6 in. will exert a force of 100 lb. at a fiber stress of 60,000 lb. per sq.in. when compressed 0.177 in. per turn.

While all springs will deflect as shown, some assumptions will result in excessive stresses. In practice this chart must be supplemented by a determination of stress. With stress S constant at 60,000 the relation between F and d is $F = kd$, where for each value of D/d, k has the value given in the accompanying table.

Each of these factors may be plotted as a curve, one of which, $F = 0.885d$ for $D/d = 8$, is plotted superposed on Fig. 5. Each point in this curve on a particular ray is located vertically above the F-scale at a point 0.885 times the ray number. Thus the point p of the curve on the ray $d = 0.19$ is vertically above 0.885×0.19 or 0.168 on F. A useful spring chart might be made by replotting Fig. 6 on a larger scale with seven curves of equal stress superposed upon it, as well as the companion curves for P for each value of D/d. This equation is $P = k'D^2$, using values given in the table for k'. Points further out on the rays beyond this curve denote higher stresses in direct proportion.

Such charts best represent equations in which the variables do not have a wide range. In those in which the values change abruptly, double sets of scale figures will enable the most suitable parts of the scale to be utilized.

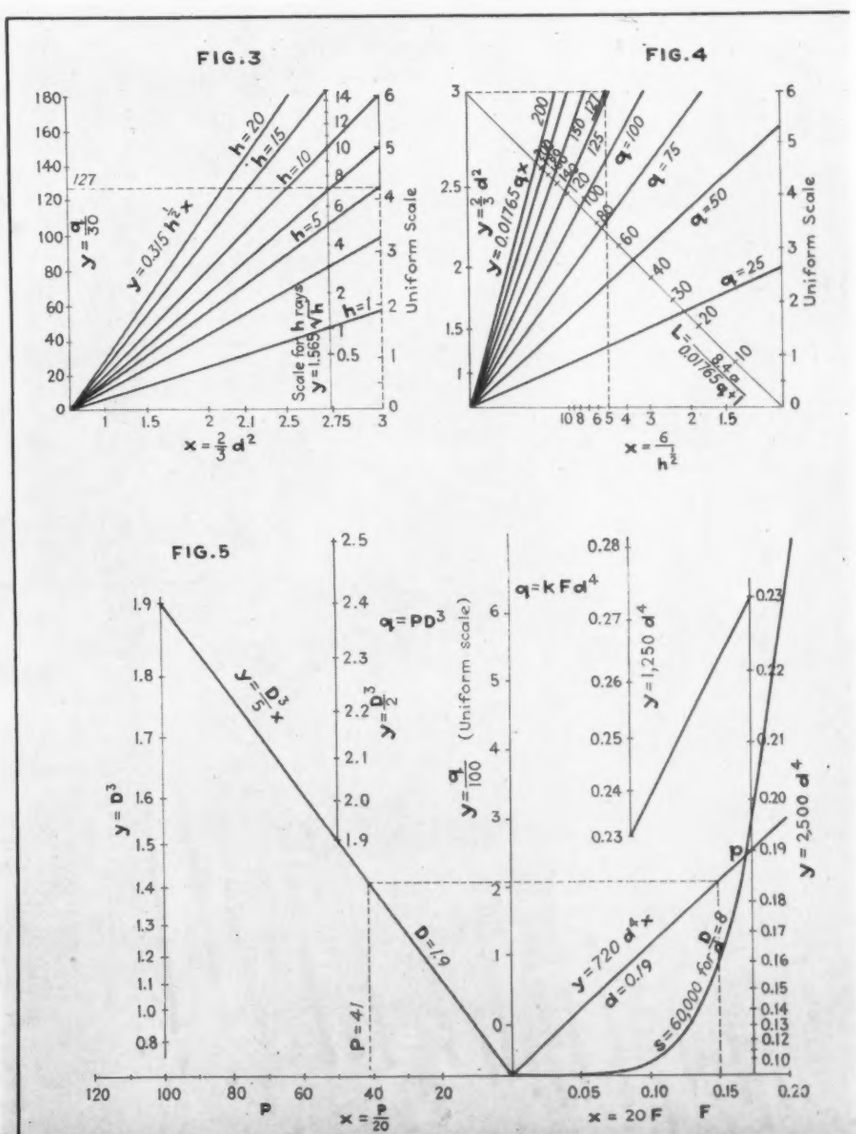
As another example, Fig. 7 plots the Barth factor f, a multiplier for the allowable static stresses in gear teeth to take account of shock. The equation is

$$f = \frac{a}{a + v}$$

The equation is a hyperbola with asymptotes $f = 0$ and $v = -a$, in which a is a constant dependent on the kind and condition of gearing. The values for a are 600, 1,200 and 3,000 respectively. Pitch-line velocity v is in ft. per min. The construction of the

Constants in the Spring Formulas

D/d	k	k'	D/d	k	k'
4	.189	66.1	8	.885	38.9
5	.314	51.5	9	1.14	35.2
6	.472	49.2	10	1.43	32.2
7	.664	43.4			



Figs. 3 and 4—In addition to the form shown in Fig. 2, the other two variables in the equation can be used for the X-axis. Fig. 5—By combining two variables, an equation with four variables can be charted in straight lines

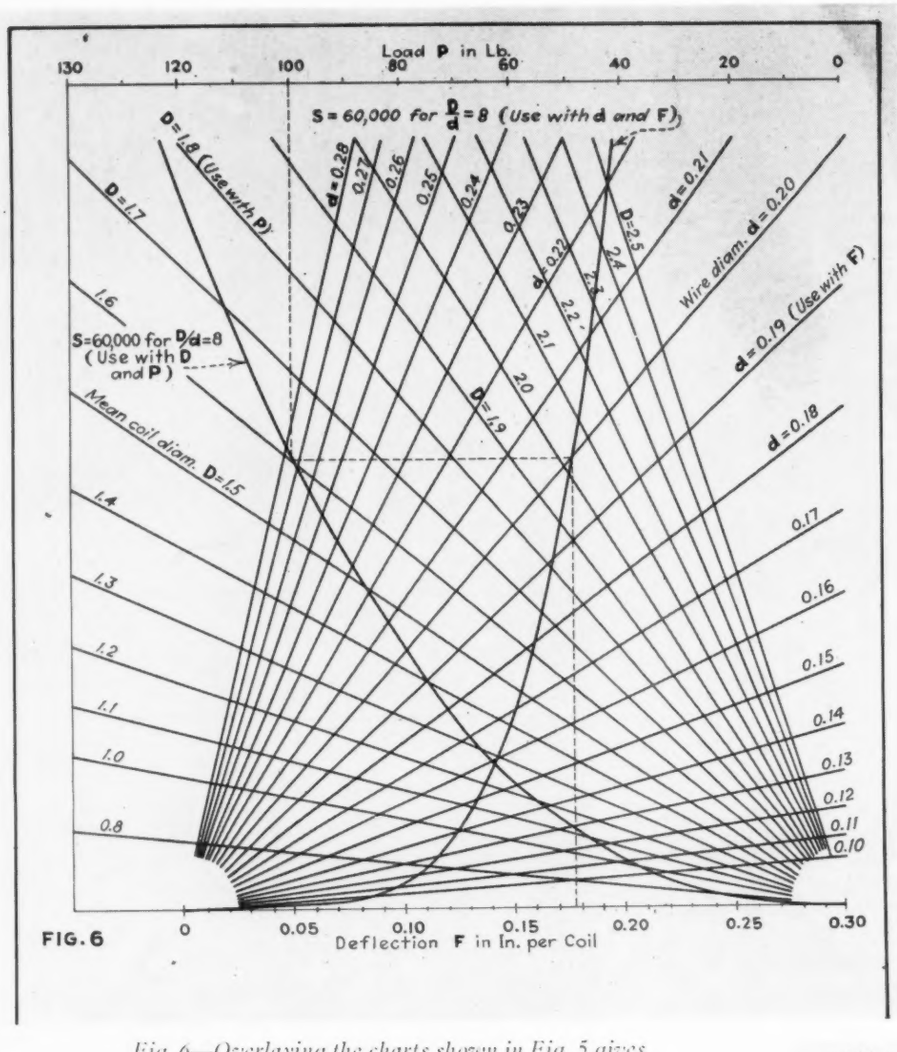


FIG. 6

Fig. 6—Overlaying the charts shown in Fig. 5 gives this simplified chart for the design of helical springs

chart is somewhat different, as the equation must be solved for v to separate the variables.

$$v = \frac{a}{f} - a$$

The equations for the coordinates are,

$$y = m_1 v = m_1 \left(\frac{a}{f} - a \right)$$

$$= m_1 \left(\frac{ax}{m_2} - a \right)$$

$$x = \frac{m_2}{f} \text{ or } \frac{1}{f} = \frac{x}{m_2}$$

The general equation for the ray is therefore,

$$y = \frac{m_1 a}{m} x - m_1 a$$

For a chart, with a maximum value of 1,200 for v and a minimum value of 0.2 for f, then $m_1 = 1/2{,}000$ and $m_2 = 1.2$. Substituting these values in the general ray equation,

$$y = \frac{ax}{2000 \times 1.2} - \frac{a}{2000}$$

$$= \frac{ax}{2400} - \frac{a}{2000}$$

With values for a as given above, the respective ray equations are,

$$y = \frac{x}{4} - 0.3$$

$$y = \frac{x}{2} - 0.6$$

$$y = \frac{5x}{4} - 1.5$$

The intercepts here are minus and are set off below the X-axis. For herring-bone gears, a fourth equation is recommended to replace the one for $a = 3{,}000$. This relation is,

$$f = \frac{78}{78 + \sqrt{v}}$$

Although it is not a straight line, this equation is shown in Fig. 7. If y is proportional to the square root of v, other relations remaining unchanged, the plot will then be a straight line. For low velocities a separate chart on more open scales will give more accurate results. As in all charts, the range for the variables must be selected to cover the conditions met in design. Where a large range is needed, a large page size may be more convenient than a series of small charts.

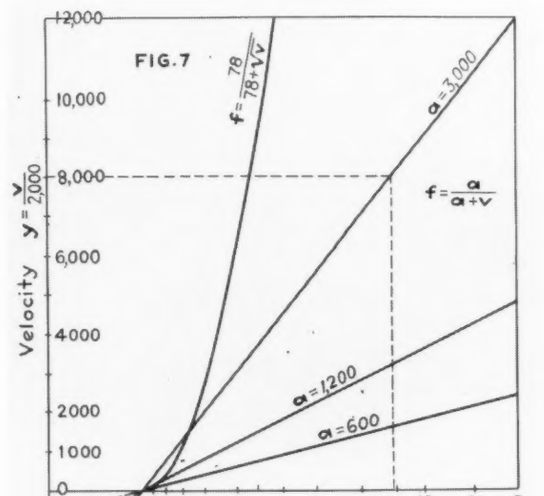


Fig. 7—Barth factor for the allowable static stress in gear teeth charted for different pitch-line velocities

Cleaning Specifications for Finishes

Standards Division—Materials and Process Engineering Department
Westinghouse Electric & Manufacturing Company

GENERAL — These specifications cover the processes to be followed in cleaning metal parts for the application of finishes. Remove scale or rust by wire brushing, scraping, sand or shot blasting, or similar method. Remove oil, grease, and similar foreign matter by one of the following methods, as specified in finish and process specifications covering the finish:

PART I—Cleaning with volatile solvents to remove oil or other foreign matter. In general, applicable to all kinds of parts, finished or unfinished.

PART II—Cleaning with hot alkaline solution to remove dirt and grease from bare metal parts, and for parts from which some paint finish is to be removed.

PART III — Cleaning galvanized parts with etching solution to obtain adhesion of paint. Required by U.S. Department of Commerce, Airways Division, Specification No. 310.

PART IV—Cleaning with hot alkaline solution. Applies to metal parts, particularly steel panels. This is a stronger cleaning solution than is used in Part II.

PART V—Stripping of paint from metal with a hot caustic solution.

PART I—*Volatile Solvents*

SOLVENTS: A number of solvents are available for removing grease and oil from metal, wood, or insulation, either finished or unfinished. They can be applied to the parts with a swab or by immersion in a dip tank. The choice of a solvent depends on various factors as follows:

(a) Benzine—This is a low-cost solvent suitable for cleaning surfaces which are to be painted or varnished. It is not suitable for cleaning parts to be lacquered due to a slight film of oil which remains after the benzine evaporates. This film frequently prevents adhesion of the lacquer.

(b) Lacquer Thinner or Toluol—These are solvents especially suited for cleaning surfaces which are to be lacquered. No residual film remains on the work after the solvents have evaporated. Change the solvents frequently to avoid contamination with oil and grease, otherwise a layer of oil may appear on the work after the solvent has evaporated and the adhesion of the lacquer film will not be satisfactory.

CAUTION: The vapors of toluol are poisonous in a cumulative manner. Both benzine and toluol are inflammable solvents, and precautions must be taken against fire or explosion. Dip tanks must be protected by automatic foam extinguishers, and provided with ventilation to prevent accumulation of vapors.

(c) Carbon Tetrachloride—This is a fireproof solvent and may be used alone or in combination with the above inflammable solvents to reduce their inflammability. The addition of at least an equal volume of carbon tetrachloride will be required to obtain this condition.. The 1-1 mixture is not inflammable, but the vapors mixed with air are explosive under certain conditions and must not be allowed to accumulate. When used in a dip tank, the tank must be protected with a fuse operated drop lid.

The mixture containing benzine, when used in dip tanks, must be kept above 1.15 specific gravity, and those mixtures containing lacquer thinner or toluol must be kept above 1.20 specific gravity.

WASHING: Immerse the parts in a tank of cleaning solution and slush about to remove oil, grease or dirt for approximately one minute, or until clean. Excess deposits of grease can be more readily dislodged by brushing while in the solution or by the application of an air blast as the piece is being raised from the tank. When using solvents in small quantities, wet a swab with the solvent, and use it to wash the surfaces to be cleaned.

WIPING: Wipe dry with clean cloths to remove dissolved grease and oil. On panels and similar pieces, excess cleaning solution can be removed readily with a cloth wiper or a felt "Squeegee." On irregular shaped pieces, an air blast is satisfactory.

DRYING: Dry parts thoroughly in air or place in an oven at approximately 110 deg. C. for half an hour or equivalent drying time. When dry the pieces shall be wiped free of dust immediately before applying a finish.

PART II—*Alkaline Solutions*

PREPARATION OF MINERAL CLEANING SOLUTION: This solution should be made up by adding 38 pounds of cleaning compound (Oakite, Wyandotte No. 140 or other equally good cleaners) to 100 gal. of water. The surface of the solution must be kept clean from scum, and the tank must be emptied and cleaned when necessary. The operating temperature should be between 80 deg. C. and 100 deg. C.

To determine strength of solution, put 10 cc. of cleaning solution in a suitably sized flask, dilute with water to about 300 cc. and add 10 cc. of diluted hydrochloric acid. (See note.) Mix thoroughly and add a few drops of methyl red indicator. If the color turns yellow, the solution is satisfactory, if the color turns red, the solution is too weak. Add 2 oz. cleaning compound per gallon of solution in tank.

(Note: The diluted hydrochloric acid is made by mixing 50 cc. C.P. hydrochloric acid with 1,000 cc. distilled water. Keep in a glass container.)

WASHING: Immerse the part to be cleaned in the solution for approximately 5 min., or until clean.

RINSING: Rinse the washed part thoroughly in clean water maintained at 80 deg. to 100 deg. C.

DRYING: Allow the part to air-dry thoroughly before applying a finish. Remove all dust or remaining film immediately before finishing by wiping with a rag wet with solvent as described in Part I.

PART III—*Etching Solutions*

CLEANING: Thoroughly clean all articles by washing with benzine.

APPLYING TREATMENT: Apply by brushing or dipping, to all hot galvanized surfaces which are to be painted, a solution made as follows:

Dissolve in 1 gal. of soft water the following:

Copper Chloride	2 oz.
Copper Nitrate	2 oz.
Sal Ammoniac	2 oz.
Hydrochloric Acid	2 oz.

This solution is to be mixed in an earthenware or glass container. Do not use a metal container. After applying allow the treated article to dry not less than 12 hr. before painting.

PART IV
Strong Alkaline Solutions

MIXING SOLUTION: Make cleaning solution as follows: Mineral Cleaner (Oakite Test Q, Magnus Chemical Cleaner 20 R, and others), 7½ oz.; Water, 1 gal.

This mixture requires 20 drops of acid when tested as follows: To de-

termine strength of solution in tank, mix the solution in the tank thoroughly and withdraw about 1 gal. for test. Allow it to cool to room temperature. Place exactly 1 cc. (measured with pipette) into a 100 cc. flask and add approximately 50 cc. of water. Add three or four drops of methyl red indicator. Then after having cleaned the pipette thoroughly of the solution to be tested, use it to add drops of normal sulphuric acid to the solution. Add one drop at a time and shake the solution thoroughly after each drop is added. The correct quantity of acid has been added when the yellow color of the solution changes to a red.

WASHING: Immerse the part to be cleaned in the solution for approximately 5 min. or until clean.

RINSING: Rinse the washed part thoroughly in clean water maintained at 90 to 100 deg. C.

DRYING: Allow the part to air-dry thoroughly before applying a finish. Remove all dust immediately before finishing. If a film remains on the work, wipe it off with a rag wet with solvent as specified in Part I.

INSPECTING: The steel panels shall be clean so that no black smudge is apparent when the panels are wiped with a white cloth or white paper.

PART V—*Stripping Solutions*

MIXING SOLUTION: Mix stripping solution as follows: Cleaning Compound (Wyandotte Enamel Remover and Others), 8 oz.; Water, 1 gal. The mixture requires 36 drops of acid when tested as specified in Part IV.

STRIPPING: The solution must be kept at about 90 deg. C. Immerse the work in the solution for as long a time as is necessary to soften and remove the paint coatings.

RINSING: After stripping, the metal parts are to be rinsed thoroughly in clean hot water.

Specifications for Painting and Lacquering

Standards Division—Materials and Process Engineering Department
Westinghouse Electric & Manufacturing Company

PREPARATION OF THE SURFACE: Failure to recognize the importance of proper preparation of the surface to be finished is responsible for many poor results obtained. No matter how good the paint may be, it will be a failure from a protection standpoint if applied over a wet, dirty, rusty, greasy, or improperly prepared surface. Be certain that the surface is clean, dry, and free from rust and scale. If rust and scale are not properly removed, corrosion may continue under the paint film, as rust and scale have the characteristics of absorbing and holding moisture. It is essential that no moisture be sealed in by the application of paint.

Shot blasting is the best method of removing rust and scale, but wire brushes, steel scrapers, chisel and hammer, and abrasive cloth are also effective. Cleaned surfaces must be painted at once, or the benefits derived from cleaning will be lost. Cold metal brought in from the outside must reach room temperature before painting or trouble will be experienced with drying, and the finish will not be durable due to the presence of condensed moisture on the surface of the metal, which frequently causes rusting under the paint film.

Refer to "Cleaning Specifications for Finishes" for methods of removing grease and dirt. Cleaning fluid must be frequently changed to avoid contamination with oil and grease, or it will become a mixture of oil and solvent and leave a layer of oil on the work after the solvent has evaporated.

APPLYING THE PAINT: Faulty application is classed as one of the greatest causes of paint defects. A paint film that is porous has little value as a protective coating. Each coat must be smooth and thick enough so that the under surface does not show through at any point, and must have a uniform wet appearance.

When brushing, work the paint well into the brush before starting to paint. Cover the surface uniformly, brushing the paint on with overlapped strokes. Avoid brush marks and runs as much as possible.

Use good brushes and take care of them. Do not put brushes into water as it makes the bristles soft and flabby. Suspend the brushes in paint or in paint thinner and linseed oil when not in use, so that the bristles are completely immersed. Do not stand the brushes on end, as this causes bristles to bend. Brushes may be cleaned for storage by washing them several times in clean paint thinner. Shake the paint out of the heel of the brush after each washing. Then wash thoroughly with soap and water, straighten the bristles, and allow to dry.

New brushes should not be used for the final coats of paint. Use them on the priming coats until the short loose bristles are worked out.

When spraying, apply uniform films which are continuous and unbroken at any point and which have a glossy, wet appearance. Spray the material wet enough to flow out smoothly. If material is too wet, runs or sags will appear. Use a cone shaped spray for painting small parts, pipes, angle iron, and small or narrow surfaces. Use a fan shaped spray for painting large areas. Move the spray gun with a steady motion and at such a speed over the entire surface as will produce a wet, glossy film, and avoid a variation in the film thickness. Each stroke of the gun, as in brushing, shall overlap the previous stroke from $\frac{1}{3}$ to $\frac{1}{2}$ the width of the spray coat, so as to produce a uniformly and completely covered surface. This overlapping is necessary because the edges of a sprayed coat are thin and porous, even where it seems to cover well.

Avoid spraying a film which has a dry, dusty appearance, as such a film is porous and will not protect the surface. This is caused by holding the spray gun too far away from the work and at too steep an angle, or by not having enough thinner in the material which is thereby not well atomized. In applying lacquers, it is necessary to hold the spray gun closer to the work than when applying oil type materials. Best results are obtained at about 6 to 10 in. with the gun held so that the material strikes the work at an angle of 60 to 90 deg. Use the lowest air pressure that will atomize the paint and produce smooth paint films. Generally this will be between 30-40 lb. per sq.in. on suction cup spray guns, and 40-80 lb. per sq.in. on pressure tank systems.

For pressure tank systems, use the lowest air pressure in the tank that will give a slow flow of paint from the spray gun when the atomizing pressure is turned off. This varies from 5 lb. per sq.in. for varnishes and light weight paints to 12 lb. per sq.in. for heavy paints. When too much pressure is applied, more paint is delivered to the nozzle than can be properly atomized by the air pressure at the nozzle. Increasing the pressure in the tank requires an increase in the atomizing pressure to prevent runs and sags and to produce a smooth uniform paint film.

[EDITOR'S NOTE—*These specifications will be continued in the February number, in addition to which there will be presented specifications for typical finishing systems.*]

Pitting of Stainless Steel By Leather

J. N. SMITH
E. F. Houghton & Company

Fig. 3—Pitting of a stainless steel valve shaft that occurred while the shaft was stored with leather packing in place

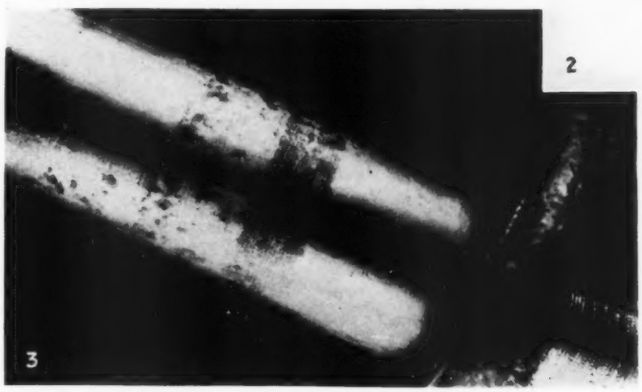


Fig. 1—Ordinary leather packing cut away showing extent of pitting occurring on a stainless steel shaft during six weeks' storage in a humid atmosphere

Fig. 2—Under same test conditions as in Fig. 1, the corrosion-inhibiting leather packing does not pit stainless steel after six months' exposure

BECAUSE of its resistance to corrosion, stainless steel is being used more and more by manufacturers of valves, pump shafts, ball bearings and many other parts. While it is true that stainless steel is not attacked in presence of many gases, liquids, and solids, it is subject to the type of attack shown in Fig. 1 when used against leather.

When pitting was first noticed in steam valves with stainless steel shafts, tests on the water did not disclose any cause for attacks. Tests on the steel did not show any scale marks or other defects that could act as a source of pitting. Then it was found that pit marks appeared on stainless steel valve stems before being placed in service, while no further attack was noticed as long as the valve stems were in operation.

Examination of shafts stored in a humid atmosphere with the leather flange packing in place disclosed that the pitting occurred only where the lip of the packing came in contact with the stainless steel. Under such conditions only six weeks' time resulted in the pitting shown in Fig. 1. Thus, the problem became one for the packing manufacturer.

Believing that certain salts or tanning materials in the leather might be the cause, the pitting was studied from a chemical standpoint. But investigation disclosed that the action was electrolytic rather than chemical. The leather absorbed moisture, and the moisture reacted with salts in the leather to set up an electrolyte causing an electroplating action. The stainless steel was removed and deposited in the leather.

Tests conducted on various types of leather indicated that all leather caused pitting. However, in some types of oak-tanned leather pitting developed faster than in other types. In the first attempt to control pitting, the type of leather that was the least active was washed in an endeavor to dilute the salt content. This helped some, but washing alone was not sufficient.

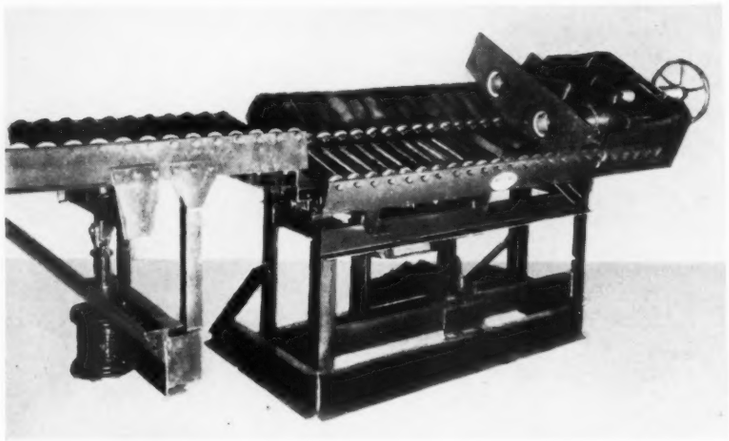
Attention was then directed to the development of a filler material that would prevent pitting. After an extensive series of tests, a filler was found that neutralized the salts and acids in the leather, thereby eliminating electrolytic action. This treatment was found to be effective for all types of leather.

As shown in Fig. 2, leather treated with the new filler material does not attack stainless steel. This packing was subjected for six months to the same atmosphere that caused the pitting shown in Fig. 1 in six weeks, and can also be compared with the valve shaft shown in Fig. 3. This pitting is typical of the attack on stainless steel shafts when stored with ordinary leather packings in place. In any application in which leather packings may be in continuous contact with stainless steel, leather should be treated with a corrosion inhibitor to prevent pitting.

QUESTION AND COMMENT

Arc Welding in Conveying Equipment

A. F. DAVIS
Vice-President, The Lincoln Electric Company



Arc welded construction combines rigidity and reduced weight in the Mathews tilting mechanism for a steel coil conveyor

● As an indication of the severe service which arc welded construction must enable conveying equipment to withstand, the mechanism illustrated in Fig. 1 is used for tilting 4,000 pound coils in steel mills. This tilting mechanism, built by Mathews Conveyor Company, is a section of a troughed roller conveyor which brings coils from storage to a decoiler and roller leveler.

The rollers of the tilting mechanism are set at an angle of 10 deg. to form a troughed roller bed on which the coils travel on their sides by gravity to the adjustable spring bumper on the tilting section. This spring bumper absorbs the impact of the coils as they come into the section. The bumper plate is adjustable for different length coils, allowing only one coil on the tilting section at a time.

In construction, all structural members of the tilting table are welded into one integral unit, with the exception of bearing mountings and other detachable parts. Only standard shapes are used. The various parts are merely cut to the required length and welded.

The base of the table frame is made up of four pieces of standard eight-inch channels welded together. The two end pieces of the bottom frame extend out on one side to provide a firm support. A section of angle welded to the extending base channel at either end, and also welded to the adjacent upright acts as a brace.

The four corner uprights are made of four-inch by four-inch angles welded to the eight-inch base channels. Welded to the top of the uprights and extending lengthwise of the unit are two standard six-inch channels. Two angles, seven inches by three inches, welded to the uprights complete the table frame and support the tilting mechanism. Additional strength is provided the frame by a longitudinal six-inch channel welded to two of the uprights and extending along one side of the unit. This, together with a shorter channel section welded in place between two upright intermediate channels, supports two transverse angles which anchor the tilting mechanism.

The frame of the buffer which receives the impact of the coils coming onto the tilting section is built up entirely of standard plate and tubing. Pieces of inch plate cut into proper lengths, are welded together. The tubular housing for the coil springs is welded to the bumper plate and frame.

In operation, the coils are placed on the head end of a 100 foot conveyor line by overhead crane and are allowed to travel by gravity toward the kick-off section. The section of the conveyor just ahead of the tilting section is fitted with pneumatically operated brake shoes which are used to slacken the speed of the coils before they enter the tilting section.

This speed slackening is accomplished by placing air cylinders underneath the points at which braking of the rollers is desired and mounting on the arm of each cylinder a member on which cup shaped brake shoes are placed. These brake shoes engage the outer surface of each roller for a distance of about 90 degrees.

The rigidity and reduced cost of the arc welded construction, as well as the fact that it permits considerably less handling in fabrication, are considerations which led this company to adopt arc welding as standard practice.

Airplane Colors

● *To the Editor:*

In his article "Color Reactions on the Senses" in the September number, Howard Ketcham mentions cockpit glare as undesirable; so is cabin glare. In flying certain courses, with certain apparent altitudes of the sun, bad glare from the wings of low wing monoplanes is encountered. Knowing the course, the time, the surface geometry of the ship and its flying attitude, zones of high reflectivity can be determined. For these areas a color scheme should include colors of highest absorption.

Attractive composition and combination of color is possible even with this restriction, if demanded. If the surfaces are aluminum they may be either dyed or painted with enamel or lacquer. But can the dyeing processes yield colors that are fast against weather, resistant to shop handling and available in all standard shades? If the dyeing process meets these requirements, then the composition of the color scheme will be limited by size and disposition of the skin sheets, which in turn are established by stress rather than by apperance considerations. If so finished, the ship would look like a checker board.

If the dyeing process is not suitable, then coloring will require a primer and enamel or lacquer on a surface that is clean and grease free. Often, skin sheets are formed, anoded, primed

and mounted, and color coats are applied after erection. Anoding provides an excellent mechanical anchorage for paint, but the anoding cost is equivalent to that of the dyeing process, and the cost of subsequent painting is added.

The outer surface of a monoplane of 750 sq.ft. of wing area is around 2,800 sq.ft. Primer and lacquer or enamel to cover this surface will add some to the gross weight. The use of Alclad skin sheeting involves a sacrifice in specific strength to attain corrosion resistance, and a weight increase. Since the load factor is specified by the Department of Commerce, the skin weight in most designs is already high enough without adding any paint weight.

External paint costs money to apply and to maintain, does not contribute to structural strength, increases time for delivery and reduces pay or fuel load. With increasing traffic density the first step taken is to find means of increasing payload without reducing range unduly, so as to minimize capital invested, and payload is not increased by piling on paint. For much lower cost and weight window curtains can be fitted.

The general shape of the present type of all-metal low wing transport has evolved from the necessity for a simple retractable landing gear, good engine position for balance and effective propoulsion, and safety in "belly-landing." In such ships the average passenger is sold a ringside seat from which he can become familiar with half an acre or so of light allow sheet dotted with a million rivet heads. As a means of shutting out both sun glare and the monotonous "wingscape" shades or curtains appear to be the best solution.

Passengers purchase transportation and expect safety, speed, comfort and dependability. Operators endeavor to furnish these four things at a price the customer can afford to pay, and at which the operator can continue in business. Under these circumstances, on an organized transport line, is the matter of external color of such vital importance?

—Roland V. Hutchinson
Lansing, Mich.

● *The the Editor:*

Over-all color treatment would add appreciably to gross weight. That is why no mention was made in the article of solid color treatment. However, most transport operating companies make practical use of distinctive, ornamental and effective looking lines of color to impart appeal to the exterior appearance of their passenger planes. This is the color treatment referred to in the article.

Pan American Airways, American Airways, United Airlines and Transcontinental and Western Air, Inc., recently have expressed considerable interest in the interior as well as the exterior color treatment of their planes. All but one of these concerns has deemed the color problem of their transport lines of sufficient value to justify an investment in color engineering.

—Howard Ketcham
New York, N. Y.

Measuring Performance of Friction Facings

E. R. FISH
Chief Engineer
W. C. Lipe Company

● Friction facings for clutches and brakes must be selected on the basis of life under load conditions that exist in service. Such factors as wear, coefficient of friction, heat generated, bleeding of filler and ash residue must be determined accurately. Friction materials to be tested are placed on the machine shown in Fig. 1 between the two disks, one driven by a 50-hp., three-speed motor. The other disk is held stationary by a torque arm connected to a spring scale. Pressure against the friction facing is obtained from a 50-lb. movable weight on the scale arm.

Instruments designed into the machine give a continuous indication of four variables; wear, coefficient of expansion, temperature and friction. Wear and expansion is indicated by a small dial gage with the gage stylus resting against the stationary disk. A spring scale connected to the torque arm measures the friction torque and a mercury-filled expansion thermometer with the sensitive thermal member imbedded in the stationary plate measures the temperature of the friction facing at the surface.

In typical tests under constant slipping load, the coefficient of friction over a range of temperature is shown in Fig. 2, for four different friction materials. In each test a normal pressure of 675 lb., or 21 lb. per sq.in., of facing area was set up by the weight. Then, the driven disk was rotated at 1,500 r.p.m. and the friction torque read as the facing temperature increased. The facing temperature reached 500 deg. F. in 12 to 15 min. of continuous operation in each of the tests shown.

Engineering Index Appeals for Support

● The following letter speaks for itself. *Engineering Index* is not a business venture but a professional institution without profit motive. It is endorsed by the major engineering

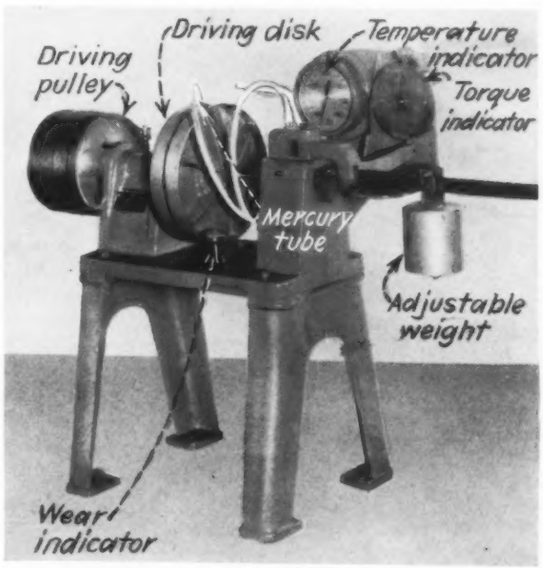


Fig. 1 — In a testing machine built by W. C. Lipe Company built-in instruments give direct indications of friction, temperature and wear in clutch facings under test

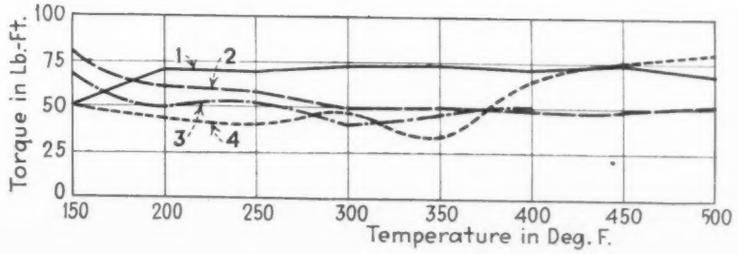


Fig. 2 — Effect of temperature on the coefficient of friction for four types of facing materials

societies, from some of which it has received financial support in the past.

All important articles that appear in both English and foreign language engineering publications are classified and indexed in the *Engineering Index* by fields and subject matter. Use of the *Index* enables an engineer to assemble quickly all the articles on a particular subject.

To the Editor:

● American engineers need the *Engineering Index* just as the lawyer needs the *Reported Decisions*, the doctor needs the *Index Medicus*, the chemist needs *Chemical Abstracts*. For engineers it is the sole index of current technical literature which is authoritative, complete and up-to-date.

For every designer, whether he uses it today or tomorrow, or even if he does not happen to use it at all, the Index should be instantly available in case he should find it necessary to learn what others have found or are doing along a particular line. Were the *Index* to cease to function, such information regarding progress in engineering science would almost immediately become unavailable.

Because of the great cost of assembling and classifying the wealth of information, the *Index* has been in financial straits. To save and perpetuate this tool so necessary to engineering science, a group of engineers, educators and industrialists, headed by Dean Collins P. Bliss, Dr. Frank B. Jewett and Dr. John V. N. Dorr, are undertaking to raise a working capital fund to see the *Index* through a five year period under a plan to make it self-sustaining at the end of that time. The appeal is directed to American industrial corporations which benefit directly or indirectly through the application of engineering science.

This approach is necessarily upon the broad principle that American industry is indeed mutually interdependent, and that the obligation to keep technical information available to all, in an organized, classified manner is a general obligation applying to all in the industrial community.

The appeal for funds was begun last spring. To date a number of corporations have generously responded, with contributions ranging from a few hundred dollars up to ten thousand. But more funds will be needed. They will be needed sorely, and, although payments may be spread over five years, assurance that they will be forthcoming, must be given now.

The *Index* must live on. The dependence of industry upon engineering science, the pride of the engineer in his profession, alike demand it. To every captain of industry we say without reservation:

"No cause of which we know is more justly entitled to your support; none will return more certain benefits to the industrial community. As liberally as you can, contribute to the fund that will make perpetual the truly invaluable service which the *Engineering Index* gives."

—Collins P. Bliss
President
Engineering Index National Committee

Tight Setscrews

To the Editor:

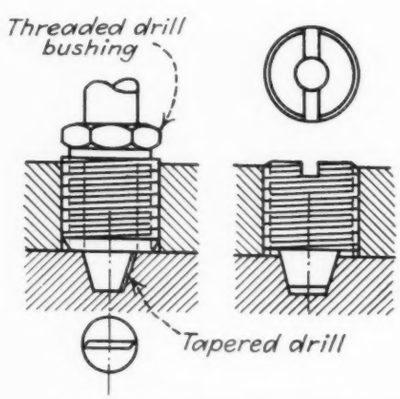
● In *Product Engineering*, September number, John E. Hyler mentions that in order to permit a setscrew to get a good hold on a shaft it might have a dog point and that the hole to receive the point could be drilled with a special seating tool, a sort of screwed drill making use of the tapped hole to get the drilling pressure.

I am afraid that unless the thread were unusually fine this scheme would fail—the feed would be too fast for the drill. As already proved in several works in England, the parallel point has the fault that under continued stresses it tends to work loose. By several concerns it has been abandoned in favor of that illustrated in the accompanying sketch which also shows the means for fitting it.

The part to be held is secured with a screwed drill bushing which is used to guide a flat-ended drill as shown. Sufficient drill bushings (hardened) are provided for a complete batch of work so that all the parts can be completely assembled and positioned before drilling starts.

One manufacturer of hollow setscrews (in the U.S.A.) had at one time a large trade in these taper-pointed screws in England. No doubt that or some other screw concern would be willing to supply the screws if required in sufficiently large quantities. If not, the screws could be home-made but of the type shown, designed to employ a screwdriver of fair strength.

—Francis W. Shaw
Whitworth, England.



A taper-pointed setscrew that will not work loose. The threaded bushing locates the taper drill

Wrong Steel Specified

● In the article "Nickel-Alloy Gear Materials and Their Heat-Treatments," in the October number, the second paragraph on page 371 incorrectly refers to SAE 2450. The correct specification is SAE 2350 for applications requiring a high quality gear of small or medium sections.

Patent Laws Should Be Scrapped

To the Editor:

● I know nothing about the American Economics Foundation except what you mentioned in the editorial in the May number of *Product Engineering*. What or who they are makes little difference to me. Even though they were wolves in sheep's clothing, I believe I would rather espouse their cause than to try to justify the present patent system, as it appears you have elected to do. Praise for the present patent system will find many more sympathetic readers among patent attorneys than among engineers or manufacturers.

The first paragraph of your May, 1935, editorial begins, "Encouraged by the monopolistic privileges granted by patents, American initiative and inventive ingenuity created the products which are the foundation of our industrial enterprises." This is not responsible for most of our scientific discoveries or mechanical inventions. The very natures of the men usually engaged in such work is entirely at odds with such a statement. Many of them if working independently have applied for patents only to record their claim to invention or to prevent someone, having knowledge of their work, from raising the question as to who is entitled to credit. Naturally, the majority want success as measured by dollars and cents, but the spirit which drives them to real accomplishment is the urge to solve any problem and a more or less academic joy in achievement.

For instance, the early inventions of Pupin were not patented until he was persuaded to do so by friends. In his biography "From Imigrant to Inventor," Mr. Pupin says, "The opinion

of the highest telephone authority in the world that my solution of the La Grangian problem has a very important technical value was more gratifying to me than all the money in the world."

You discuss in the second paragraph the distribution of profits, if any, from patents and state that "less than one out of 1,000 patents get beyond the development stages; even fewer show a profit." Isn't it evident that there is something wrong with the system when out of 1,000 so-called inventions something less than one should be profitable? Just what percentage of applications are granted, I do not know, but think what a price the American public is paying for something it does not get. Each application usually requires a preliminary search for possible previous conception, maybe a much more costly complete search. Then there is the preparation of the application and the usually numerous resubmittals before the patent issues. After it is granted it means absoluely nothing until it is tried in the courts and the patentee must have the price to carry it through. When it is all through, he has one chance in eight of having a valid patent.

In the third paragraph you state "Our patent system was instituted for the purpose of guaranteeing to inventors the exploitation of their patents free of competition." Honestly, does the patent system guarantee anything, with the excepion of the occupation of a much too large number of our better educated and more ingenious individuals in the profession of patent attorneys? How can it profess to guarantee free exploitation or protection to the inventor when he must after spending a considerable amount for his patent, still risk a law suit of very indefinite proportions, if he considers his patent infringed? He must do the protecting himself and knows before he starts that he has one chance in eight of finding his so-called patent worth anything.

You state that one of the purposes of the American Economic Foundation is to oppose the "abuses" of the patent system. That certainly is a big job, for one has to have very little to do with patent transactions before coming in contact with many serious injustices. For instance, right now there is a law suit threatened where two patents evidently conflict. Both applications were prepared by the same partnership of patent attorneys. In the threatened suit one member of the firm under his own name represents the plaintiff, the other member in his own name represents the defendant. In other words, these two companies pay the attorneys hundreds (maybe thousands) of dollars to secure for them valid patents.

Consequently, our patent system as it is now constituted defeats its own purpose; the public would be better served, research would be just as attractive, and progress would be just as rapid if the whole system was gradually discontinued. If the patent attorneys and the patent office do not cooperate to change the percentage of tested patents found valid to something like seven out of eight good rather than one out of eight good, it seems inevitable that either the government must protect the patents it grants or recognize the system as a farce.

It is possible that the professors you mention in your August, 1935, editorial really are not "inviting scorn or derision upon themselves and their profession." Maybe theirs is a "voice crying in the wilderness."

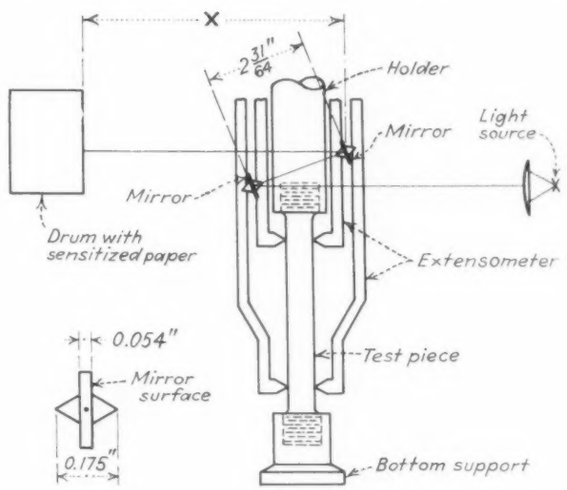
—H. N. Booker
Lancaster, Ohio.

Dimensions Wanted for Optical Extensometer

To the Editor:

● In a Martens mirror extensometer used to measure the elongation of a tensile specimen, a magnification of 1,000 is desired. With the dimensions shown in the accompanying diagram, at what distance must the recording drum be placed to obtain this magnification?

—W. W. Mohr
East Chicago, Ind.



What dimension x will give a magnification of 1,000 for this optical extensometer?

Cooperation on New Design

To the Editor:

● When new designs meet with psychological inertia on the production line, the wise thing is not to ignore them, but to face the facts and make the best of it. If and when foremen become touchy, and mechanics under them become disgruntled, grouchy or next thing to rebellious, they are not in a position to add that indispensable help which helps in making a new design of any kind a thorough-going success.

Designers are liable to overlook the fact that departmental foreman and their mechanics are always at a tremendous disadvantage where new design is concerned. The foreman who is suddenly faced with a new set of prints does not and cannot stand on an equal footing with the engineer who has pored over a design.

It is not always good strategy to send the engineer into the shop to impart the necessary knowledge on a given design to the various departments. This may be done to advantage only in those cases where the designer possesses a great deal of tact as well as teaching ability. The least show of a high hat manner or of impatience on his part will immediately engender a quiet opposition that ends all hope for full cooperation.

One means for obtaining cooperative effort is to submit new designs to a shop conference for comment, for questions, and for general discussion as to advantageous means and methods of production. In the conference will be included departmental foremen, designers, and a representative number of higher-class mechanics. This method allows time for the design to "soak in" without embarrassment to anyone, and often brings forth suggestions of value both on the design and its production, and engenders the feeling that it is "our" problem.

—John E. Hyler
Peoria, Ill.

Anti-Friction Bearings

E. WOOLER
Chief Engineer, The Timken Roller Bearing Company

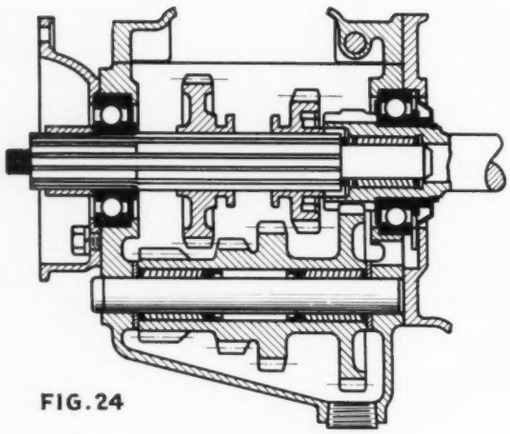


FIG. 24

IN THIS concluding article, ten typical applications of ball and roller bearings are shown for transmissions, steering mechanisms, universal joints, generator, and front wheel drives that have been used in automobiles.

Fig. 24—The use of ball bearings predominate in passenger car transmission, but in commercial vehicles both straight and tapered roller bearings are used extensively in transmission because of the more severe loads. In this spur gear transmission the drive shaft is mounted on ball bearings. The countershaft rotates on two long roller bearings, and the pilot bearing is of the same type.

Fig. 25—Until recently most transmissions were of the straight spur gear type, but now the constant mesh helical gear transmission is in general use. In this typical transmission, the tooth spiral angles are so arranged that the gear thrust is taken directly on the ball bearing nearest the gear. Snap rings act as shoulders for the bearing outer races, making possible through-bored holes.

Fig. 26—The main shaft of a large truck transmission is supported by three ball bearings. Each constant mesh gear is mounted on two tapered roller bearings, these idling gears being engaged by toothed clutches. The drive shaft is piloted on a long roller bearing.

Fig. 27—Both the main shaft and freewheeling unit are supported by tapered roller bearings. The thrust reaction from the tapered bearing is taken by four balls on the end of the main shaft, the radial load being supported by a straight roller pilot bearing.

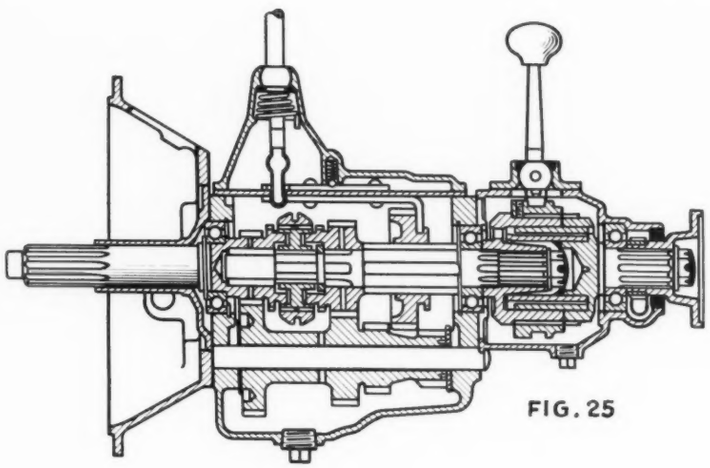


FIG. 25

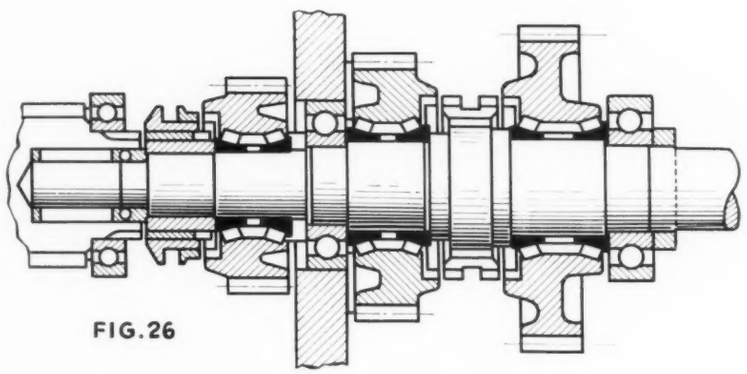


FIG. 26

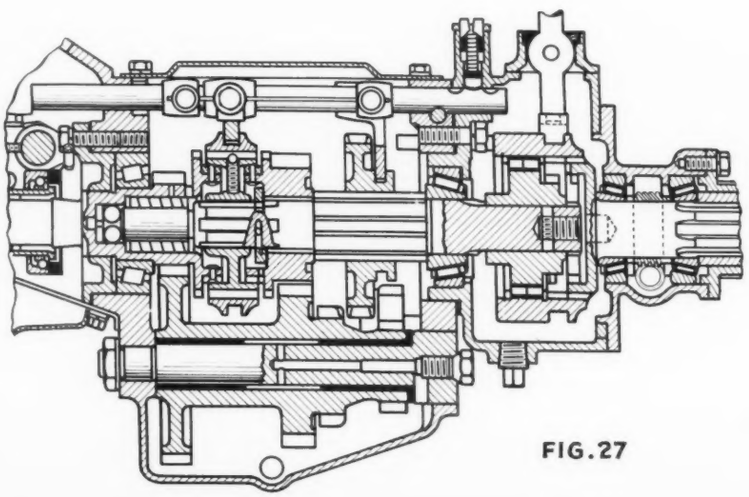


FIG. 27

in Automobiles–III

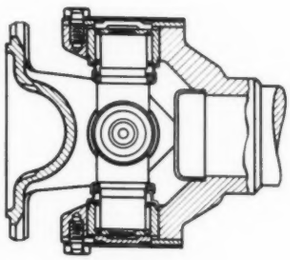


FIG. 29

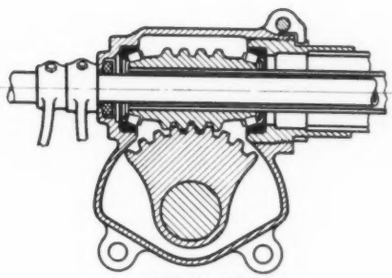


FIG. 30

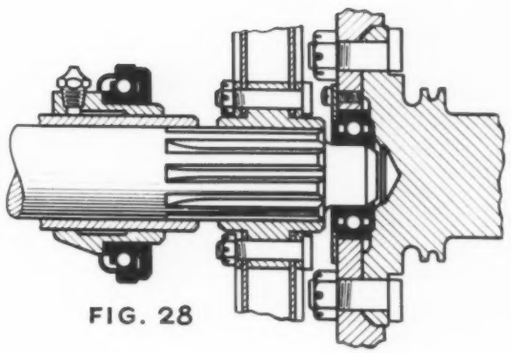


FIG. 28

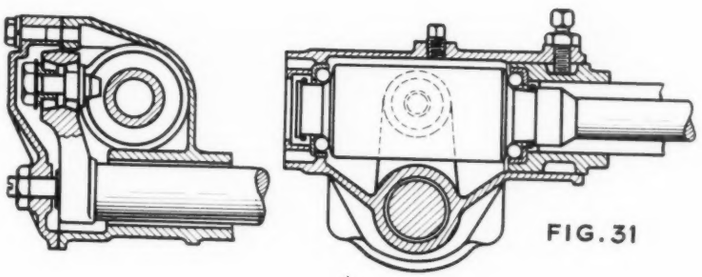


FIG. 31

FIG. 32

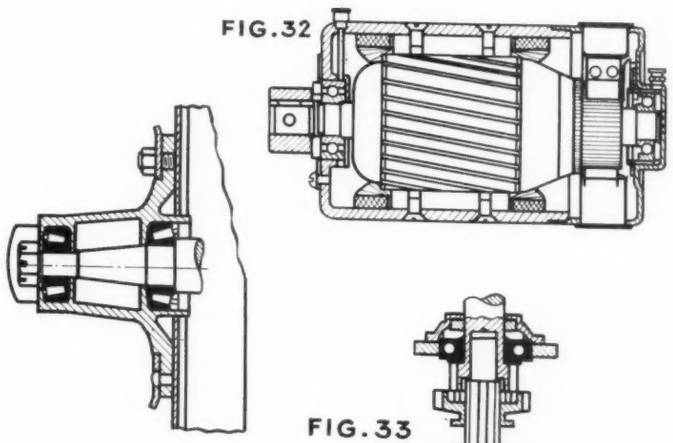


FIG. 33

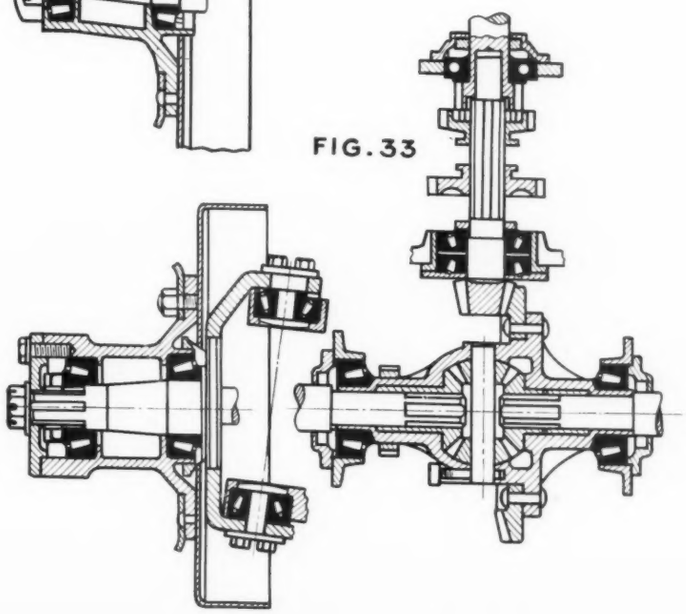


Fig. 28—In a unit power plant type of transmission the forward end of the clutch shaft is supported on a ball bearing. Although the service is not severe, adequate means must be provided for lubrication. The bearing is held in place by a plate which also retains the original filling of grease. The clutch throw-out ball bearing is of the conventional type.

Fig. 29—This universal joint spider oscillates on a full set of small diameter rollers bearing in hardened cups, a type commonly designated as "needle bearings." The advantage of this type of bearing is that it retains the initial lubricant supply between the rollers.

Fig. 30—An example of a small conventional worm and segment steering gear. The self-contained cage and roller assembly of the tapered roller bearing is mounted directly on either end of the hardened and ground worm. This mounting eliminates extra pieces necessary with the standard type of bearing. Approximately 80 per cent efficiency is attainable in steering gear mechanisms mounted on anti-friction bearings whereas 40 per cent was the best when plain bearings were used.

Fig. 31—Worm thrust in this steering mechanism is taken in both directions by ball bearing, the inner race being the worm itself. The tapered roller bearings of the follower roller bear directly against the heat-treated lever forging.

Fig. 32—Ball bearings are used extensively for supporting the armature shaft of generators. Magneto type or annular non-separable types of ball bearings are used. Seals prevent the lubricant from reaching the inside of the generator.

Fig. 33—The bearing problems in front wheel drives differ but little from the conventional rear drive. In this front drive installation tapered roller bearings are used throughout with the exception of the clutch throwout bearing. Another type of wheel mounting is shown.

NEWS

Papers on Design at A.S.M.E. Meeting

NUMEROUS papers dealing with mechanical design problems will be presented at the annual meeting of the American Society of Mechanical Engineers to be held in New York City, December 2-6. The technical sessions will be held December 1 to 5 inclusive.

On Tuesday morning, December 3, the Railroad Division will hold its first session at which A. I. Lipetz will present the report of his committee on "Progress in Railroad Mechanical Engineering." At the afternoon session of the Railroad Division, on the same day, E. S. Pearce will present a paper entitled "Locomotive and Car Journal Lubrication." Simultaneously there will be a session of the Applied Mechanics Division at which R. W. Bailey will present a paper on "Design Aspects of Creep." Other papers at this latter session will be "A Method of Analyzing Creep Data," by R. G. Sturm, C. Dumont and F. M. Howell; "The Creep of Metals," by A. Nadai and E. A. Davis; and a paper "Residual Stresses in Cold-Drawn Brass Tubes," by C. G. Anderson.

At the morning session of the Iron and Steel Division, Wednesday, December 4, there will be a paper by J. R. Connelly and C. C. Hertel on "Bearing Investigation by the Varying Wear Method," the results of researches conducted at Lehigh University.

At the session of the Textiles Division, held simultaneously, there will be a paper by R. DeVere Hope on "Power Applications and Other Mechanical Features in Connection with Textile Printing."

Papers to be presented at the afternoon sessions on Wednesday, December 4, include "Stresses in Three-Dimensional Pipe Bends," by William Hovgaard; "Creep of Steels as Influenced by Micro-structure," by L. L. Wyman; "Lateral Oscillations of Rail Vehicles," by B. F. Langer and J. P. Shamberger.

Thursday morning, December 5, the Aeronautics Division will have a session at which three papers will be delivered—"The Design and Performance of a High-Pressure Axial Flow Fan," by L. S. Marks and Thomas Flint; "Pressure Losses in Rectangular Elbows," by Richard D. Madison and J. Richard Parker; "The Rating of Aircraft Engines," by Gaylord W. Newton.

Thursday afternoon there will be delivered papers on "Film-Lubrication Theory and Engine-Bearing Design," by E. S. Dennison; "Analysis of Plate Examples by Difference Methods and the Superposition Principle," by D. L. Holl; "Buckling and Ultimate Strength of Compressed Rectangular Plates," by S. Timoshenko.

Morning sessions will begin at 9:30 a.m. and afternoon sessions at 2 p.m. A one-third return fare railroad rate will be available to members of the American Society of Mechanical Engineers, American Society of Civil Engineers, Federated Management Association, American Ceramic Society, the Society for the Promotion of Engineering Education, the American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers. Those attending the meeting and who wish to avail themselves of the one-third return fare privilege should secure certificates which will entitle them to return tickets at the rate of one-third the regular one-way fare.

A.S.A. to Compile New Dictionary

IT has just been announced that the compilation of a new dictionary of letter symbols and abbreviations will be undertaken by the American Standards Association. The rapid coinage of new words and terms, and the adoption of many foreign words and phrases in the various fields of engineering and sciences, has made desirable a new compilation of standard usage. To this end, the committee on symbols and abbreviations of the A.S.A. has been reorganized and will begin at once the intricate task of coordinating existing abbreviations and symbols, and rewriting the present standards into a comprehensive manual of letter symbols and abbreviations. The scope of the work reads: "Standardization of letter symbols and signs for equations and formulas, and abbreviations for use in publications."

In line with American Standards Association procedure, the committee is anxious that every group that has a problem with respect to abbreviations and symbols in its own field, be represented on the committee. Any group that has published its own standards or symbols is urged to submit a copy for consideration by the committee. Because of the difficulty involved in writing this universal simplified language for all phases of engineering, the committee is urging those interested to send comments on the standards which have already been approved and suggestions for useful new symbols and abbreviations not now included. Communications should be addressed to Dr. J. Franklin Meyer, National Bureau of Standards, Washington, D. C., chairman of the committee.

Twelve standards for letter symbols, abbreviations and graphical symbols have been developed by the technical committee of the American Standards Association, which has been at work for many years. Recently in order to simplify the work of the committee, it was divided into two parts, one covering the letter symbols and abbreviations, and a second covering the graphical symbols. Letter symbols and abbreviations cover mathematics, physics and mechanics, structural analysis, hydraulics, heat and thermodynamics, photometery and illumination, aeronautics, electric and magnetic quantities, radio, and abbreviations for scientific and engineering terms.

The committee which will prepare standards on graphical symbols will start work soon and will also request comments and suggestions on its phase of the problem.

Standards already approved by the American Standards Association and which are being studied for possible revision are: Symbols for mechanics, structural engineering and testing materials; symbols for hydraulics; symbols for heat and thermodynamics; symbols for photometry and illumination; aeronautical symbols; mathematical symbols; letter symbols for electrical quantities; graphical symbols used for electric power and wiring; graphical symbols used in radio; graphical symbols used for electric traction including railway signalling; graphical symbols for telephone and telegraph use; abbreviations for scientific and engineering terms.

Story of Stainless Told by Sound Film

WHAT is claimed to be the first sound picture on the manufacture, fabrication and application of stainless steel, was shown at a meeting of the Engineering and Construction Section of the Institute of American Meat Packers, on October 18, at the Drake Hotel in Chicago. This film, produced for Republic Steel Corporation, is described as one of the finest examples of modern industrial motion picture photography. Off-

A corner of the main room of the new laboratories of the Chicago Vitreous Enamel Product Company

screen narration describes in non-technical language the scenes which tell the story of the making of stainless steel, its fabrication and its uses.

After following through the production of stainless steel, the film depicts the more important phases of fabrication, and demonstrates how stainless steel can be welded, soldered, spun, drawn, stamped and formed. Following this the film, called "Enduro, Republic's Perfected Stainless Steel," shows installations and applications of stainless steel in widely varying fields. The subjects covered include everything from the architectural applications on the Empire State and Chrysler buildings to dainty wrist-watches and jeweled mountings. The fields of design touched upon include automotive, oil refining, dairy, food handling equipment, surgical and dental equipment, chemical manufacturing and domestic products.

The film consists of four standard reels and will be ready for distribution shortly. The production scenes of the film were taken at the Republic plants at Canton and Massillon, Ohio.

Porcelain Research Laboratory Completed

DESIGNED to be the most efficient laboratory for conducting research and developing new porcelain enamels, the extensive laboratories of the Chicago Vitreous Enamel Product Company have just been completed. A unique feature of these laboratories is the new and extensive use that has been made of porcelain enamel as a building material.

A main laboratory room, analytical chemical laboratory, office of the director of research, color and frit control laboratory, physical instrument room, experimental smelting department, smelt record room and shower and locker room, form the main divisions and occupy a total area of approximately 10,000 sq.ft. Exactly 12,718 sq.ft. of special acid-resisting "satin matt" porcelain enamel, developed for architectural purposes, was used for most of the interior finish.

Equipment in the chemical laboratory includes: electrolytic equipment for determining such elements as cobalt, nickel and copper; draft-free balance room where all weighing is done with two chain-o-matic balances; a double work table which includes combustion equipment, a muffle electric furnace for igniting precipitates and thermostatic control baking equipment; and other apparatus.

In the experimental smelting department are three experimental smelters with a capacity of from 50 to 75 lb., depending upon the type of enamel being developed, and two larger smelters with 150 lb. capacity. These smelters have individual blowers, burners, pyrometer and draft or stack controls. All experimental smelts of enamel are started in the 50-75 lb. smelters. If these are found to be satisfactory by the engineers in charge, they are transferred to the 150 lb. units, where trials of almost full scale dimensions are made. Then smelts are made in a 900 lb. smelter to make sure whether the new enamel will be adaptable for production in regular commercial smelters.

The main laboratory room has 5,000 sq.ft. of floor space and contains what is virtually three miniature porcelain enameling plants. One of them is devoted exclusively to the testing of enamel smelts; another is used for color matching purposes, and one is used for general enamel development and research. The physical testing laboratory is also in this room.

MEETINGS

American Institute of Electrical Engineers—Annual meeting, Engineering Societies Bldg., New York, N. Y., Jan. 28-31. H. H. Henline, secretary, 33 West 39th St., New York, N. Y.

Society of Automotive Engineers—Annual meeting, Book-Cadillac Hotel, Detroit, Mich., Jan. 13-17. John A. C. Warner, secretary, 29 West 39th St., New York, N. Y.

EXHIBITIONS

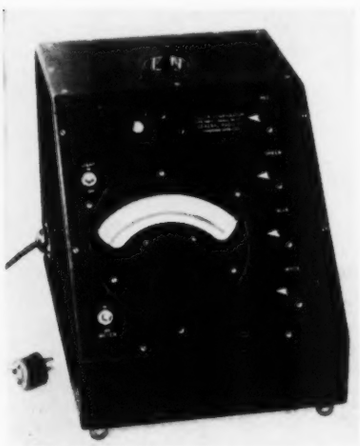
Exposition of Chemical Industries—Grand Central Palace, New York, N. Y., Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York, N. Y.

Motor Boat Show—Grand Central Palace, New York, N. Y., Jan. 17-25. Ira Hand, manager, 420 Lexington Ave., New York, N. Y.

New Materials and Parts

Color Comparator

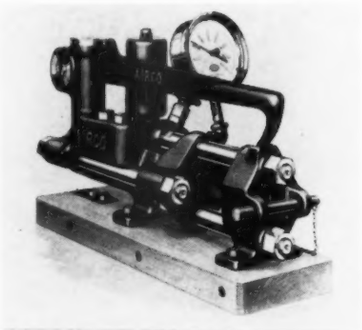
For indicating color intensity. Reflection is measured in frequency bands selected from the complex waveform by filters. In examining any color, three meter readings are obtained corresponding to the red, blue and green regions. When these readings are identical for two samples, the samples are said to be identical in hue, saturation and brilliance. The meter scale is wide and open to permit easy reading. A voltage regulator is built-in to insure constancy of light source. Operates on a.c., 115 volts, 50-60 cycles, and consumes 75 watts. The instrument weighs 40 lb. Case is 12x12x16 in. long. General Radio Co., 30 State St., Cambridge A., Mass.



Automatic Multiple Oiler

Is operated by a Telechron motor to feed one to ten drops of oil every 15, 20, 30 or 60 min. Amount of oil is adjustable through screws. The oiler contains no check valves or springs. Either light or heavy oils can be fed. Oiler is placed above the bearings and the opening in each lead is above the oil level in the reservoir. Gits Bros. Mfg. Co., 1855 S. Kilbourn Ave., Chicago, Ill.

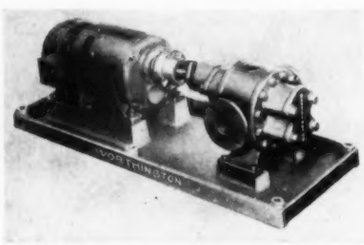
Weld-Strength Testing Machine



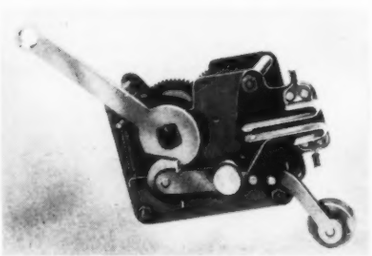
Used by engineers to test the actual strength of welds as they are made, making it unnecessary to ship weld specimens to the testing laboratory. Consists essentially of an oil-pump, a hydraulically actuated piston and four symmetrically located steel shafts. Test readings are indicated on a 6-in. pressure gage. A direct load of 40,000 lb. per sq.in. can be applied to specimens 10 in. long, $\frac{1}{2}$ in. thick and $1\frac{1}{2}$ in. wide. On smaller cross-sections, loads equivalent to more than 150,000 lb. per sq.in. can be applied. Readings are said to be accurate to plus or minus 2 per cent. For bend tests an anvil is provided which fits into the movable head. The machine is portable. Air Reduction Sales Co., Lincoln Bldg., New York, N. Y.

Rotary Pump

For pumping all kinds of clean liquids—thin, thick, hot, cold or corrosive; also liquids that solidify when cool such as asphaltum, rosin, lard, soap and other materials. Standard and steam-jacketed pumps are capable of withstanding 300 lb. per sq.in. and temperatures to 650 deg. F. with capacities from 10 to 2,500 gal. per min. The pumps are steam-jacketed for viscous and solidifying liquids and for high temperatures the stuffing boxes are water-jacketed. Sleeve and roller bearings are used internally for non-corrosive liquids and ball bearings are used externally for corrosive liquids. Double-helical gear rotors are used. The pumps are said to give a straight way, continuous, non-churning and non-foaming discharge. No valves or disks are used. Any driving arrangement is applicable. Worthington Pump & Machinery Corp., Harrison, N. J.



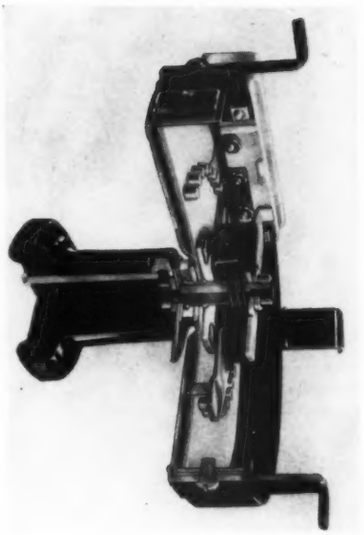
Single-Throw Timer



Is used for short time intervals. Single arm functions as switch-setting, starting and time-setting lever. Timing interval depends on distance of lever throw. The No. 10-LC timer is furnished in two timing ranges: 5 min. maximum to $1\frac{1}{2}$ min. minimun, and 50 sec. maximun to 13 sec. minimum, with or without switch. A bell-clapper is provided when required for signaling at end of timing interval. Has silver contacts for 3 amp. capacity, 110 volts, a.c., and d.c., single pole. Measures $2\frac{3}{8}$ in. wide, by $1\frac{1}{2}$ in. high, by 1 in. deep. Walser Automatic Timer Co., Graybar Bldg., New York, N. Y.

Field Rheostat

The base is made of pressed steel plate for lightness. Resistance element to which contacts are welded, is enveloped in a fused-on vitreous enamel. Steel shaft runs on graphited bronze bearing. All parts are keyed to shaft to eliminate set screws. Functions of current carrying and contact pressure are entirely separate. Contact arm is double ended for balanced construction. Handwheel is $3\frac{1}{4}$ in. diam., 3 in. high. Can be furnished with complete



inclosures, fittings for conduit connections and accessories for back-of-board, floor, concentric and motor drive. Fixed and adjustable auxiliary stops can be provided. Ward Leonard Electric Co., Mount Vernon, N. Y.

Industrial Circuit Breaker

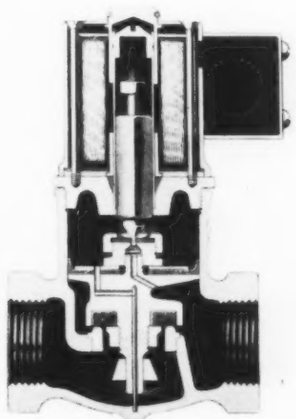
Breaker unit is mounted on a metal pan, hinged to box. Unit swings out of box for ease of wiring. Space provided in back of box for conduit and wires. Operating handle is permanently engaged with the bakelite breaker handle. Available for 15 to 50 amp., 250 volts a.c., 575 volts a.c., 125 to 250 volts d.c. and 250 volts d.c., 2 and 3 poles. Square D Co., Detroit, Mich.

Welding Cable

"Realwear" is a new type of welding cable designed to withstand wear in operation. It consists of fine tinned copper wire laid in ropes and stranded. Individual ropes are alternated in succession as regards direction of the lay to prevent distortion. The conductor is insulated with an especially developed rubber compound which is claimed to be resistant to oil, grease, acid, gasoline, moisture and heat. Available in sizes 2, 1, 0, 00, 000, and 0000, with 1,666 to 5,242 strands. The Lincoln Electric Co., Cleveland, Ohio.

Electro-Hydraulic Valve

Although designed primarily for refrigerants, the valve can be used for water, oil or air. When the electric pilot valve is closed, tight seating is obtained by a hydraulic pressure four times greater than line pressure. When the pilot valve is electrically energized, it opens and releases the hydraulic pressure, permitting the line pressure to open the main valve. It is said that the valve can be adjusted to close within one second. The Wm. Powell Co., Cincinnati, Ohio.



"Security" Nut

Has a 2-eared retainer nested in a counterbored recess in the nut. The protruding lugs prevent independent rotation of the parts. The retainer, made of alloy steel, is tapped a free fit, distorted to an elliptical shape and spring-tempered. When inserted into the recess of the nut, the pressure resulting from the elliptical shape holds the retainer against the walls of the

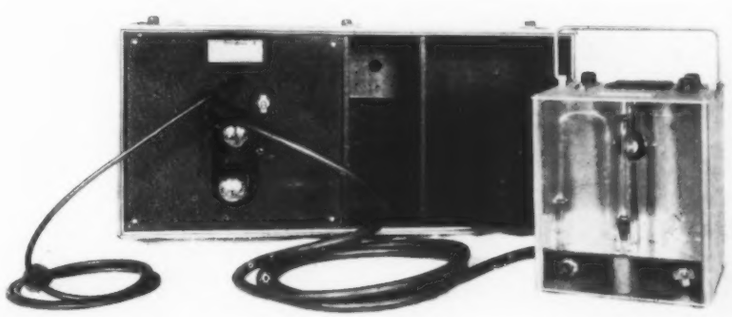
counterbore. The nut is said to be vibration-proof, requiring a wrench for loosening, but repeated application does not affect the efficiency. Available in sizes of $\frac{3}{8}$ to 2 in. diameter for U.S. coarse threads and $\frac{3}{8}$ to $1\frac{1}{2}$ U.S. fine threads. Machinery Products Corp., 2020 N. Major Ave., Chicago, Ill.

Lithoform

A new chemical applied as a coating to galvanized surfaces to which paint is said to adhere. It is claimed that the material forms an impervious, stone-like coating on the metal, preventing the formation of zinc soaps and will not wash off, chip, corrode and not to be affected by baking temperatures. It is applied by brushing or spraying and will cover 1,000 sq.ft. of surface per gallon. American Chemical Paint Co., Ambler, Pa.

Portable Stroboglow

Is based on the stroboscopic principle for study and analysis of rotating or vibrating objects. The glow lamp has a high intensity of light and is controlled from an electronic timer with primary range of 100 to 5,000 flashes per min. A secondary range to 30,000 r.p.m. is readily available by using one flash for each six revolutions. Frequency controls are located at the lamp unit. A 10-ft. cable is supplied. All parts and accessories are carried in a case measuring 26x14x10 in., weighing 55 lbs. complete. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



Automatic Time Switch

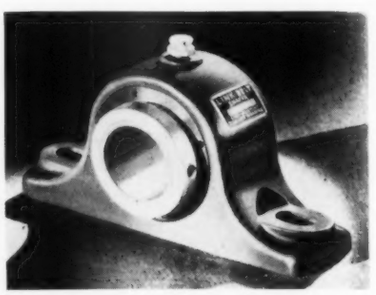
Suitable for all general purpose applications domestically and industrially such as water heaters and furnaces. Type T-17 will perform any practical number of operations per day and can be set to skip one or more days. Designed for a.c. circuits, 115 and 230 volts with current rating of 40 amp. per contact. Triple-pole switch will handle 120 amp., split load. Type T-27 is similar except that it is not equipped with a weatherproof case. Both types are direct-driven from a Telechron motor through gear-train. Switching mechanism operates quick-make and quick-break silver contacts. Six forms are available: single-throw, 1, 2 or 3 poles; double throw, 1, 2 or 3 poles. Operates in a temperature range of zero to 110 deg. F. Can be supplied to operate in range of —20 to 110 deg. F. if desired. General Electric Co., Schenectady, N. Y.

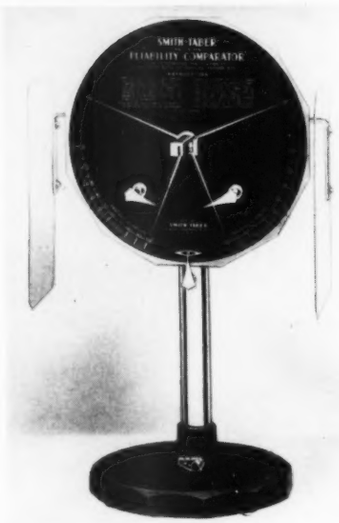
Graphited Bearings

Available in both plain and oilless types in sizes from 3/16 in. to 20 in. bore; also in bearing bronze bars both solid and cored in 13 in. lengths. Oilless bushing has square-shouldered grooves machined into bearing surface, the grooves extending to within 1/16 in. of the end of the bushing. Diamond-shaped islands of the metal give more than 75 per cent bearing surface. A graphite compound is forced into the grooves under pressure and then baked. The compound is said to be unaffected by any temperature that the bronze will withstand. The binder material used with the graphite is claimed to have lubricating value. Graphited types are also available in brass or aluminum. Federal Bronze Products Co., 17-21 Newark Way, Maplewood, N. J.

Roller Bearing Units

Series 400 Link-Belt Shafer roller bearing with double-row rollers of the self-aligning type is used for pillow-blocks, flange bearings, hangers, and take-ups. Self-alignment is provided by concave rollers running between convex outer race and spherical inner race on the sleeve. Labyrinth seals protect the bearings. Link-Belt Co., 300 W. Pershing Road, Chicago, Ill.



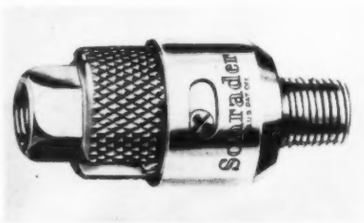


Pliability Comparator

For checking and controlling quantitative and qualitative factors relating to pliability of textiles, thin papers, transparent wrappings, suede leather and other light-weight materials. Can be used for setting up and control of sizing operations, checking laboratory runs, determination of the effect on various weaves and twists affecting pliability of fabrics and other uses. Said to give a quick and accurate check both with and against the grain of the material to be tested. Smith-Taber Co., North Tonawanda, N. Y.

Improved Brake Lining Resins

Two new Durez resins known as 175 Resin for use in conjunction with rubber linings, and 1606 Resin for impregnated woven lining are announced. The use of these thermo-setting phenolic resin products are said to have greater resistance to water, oil, and heat, resulting in a more uniform coefficient of friction. General Plastics, Inc., North Tonawanda, N. Y.

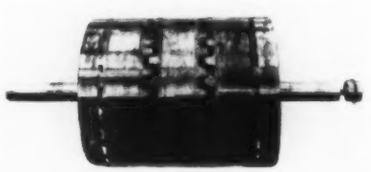


Quick-Acting Coupler

Adaptable for attaching or disconnecting airline equipment for grease, spray or blow guns, air chucks, chuck gages and other devices. Said to be as quick as plugging into an electric socket. Tripping deflator and rubber washer in the check unit are replaceable. The device is made of cadmium-plated steel. A. Schrader's Sons, 460 Vanderbilt Ave., Brooklyn, N. Y.

Magnetic Pulley

Has transverse and longitudinal radiating ducts for heat dissipation. Each coil is wound upon its own bobbin, which forms the core of the two poles. The separate bobbins are keyed to the shaft and are corrugated on the outer and inner faces. Pulley is supplied with bronze collector rings with double contact brushes for each ring, and a dust-proof housing. A steel switch cabinet contains a pilot lamp with bullseye indicator to show when current is flowing. Dings Magnetic Separator Co., Milwaukee, Wis.



MANUFACTURERS' PUBLICATIONS

Ball Bearing Spindle Applications—Marlin-Rockwell Corp., Jamestown, N. Y. Folder showing 16 basic designs of proven ball bearing spindles for internal grinding, diamond boring, hobbing, surface grinding, and routing machines. Live centers and lathe and grinder spindles also are shown.

Electrical Equipment for Machine Tools—General Electric Co., Schenectady, N. Y. Bulletin GEA-2196, 4 pages, 8x10½ in. Various types of motors and control equipment as applied to machine tools. New disk-type brake and thrustor are also illustrated.

Flexible and Cross-Type Couplings—John Waldron Corp., New Brunswick, N. J. Catalog Nos. 50 and 51, 12 and 4 pages respectively, 8½x11 in. Francke flexible and Waldron cross-type couplings illustrated. Service factors for a number of machines are given. Important changes of design and materials are described and capacity and dimension charts for various types are included.

Grinding Spindles—SKF Industries, Inc., Philadelphia, Pa. Bulletin "Smooth Grinding with SKF Bearings," 12 pages, 8½x11 in. Application of self-aligning ball and roller bearings, straight roller and ball thrust bearings to grinding spindles. Spindles are illustrated for internal, cylindrical, cutter, thread and miscellaneous grinders.

Machine Tool Applications—Norma-Hoffmann Bearings Corp., Stamford, Conn. Engineering bulletin, 22 pages, 8½x11 in. Shows typical applications of ball, roller and thrust bearings to machine spindles for drilling, boring, milling, grinding and routing. Lathe headstocks and centers and loose pulley mountings are also illustrated.

Molded Plastics—Reynolds Molded Plastics, Div. of Reynolds Spring Co., Jackson, Mich. Booklet, 20 pages, 8½x11 in. Gives a list of uses and pictures of synthetic plastic moldings made of phenol, cellulose, beetle, Durez, Plaskon, Resinox and Tenite. A short text shows the advantages and limitations of the use of plastics and contains notes on inserts, machining, physical strengths, tolerances, dielectric strengths, heat and finish.

Self-Aligning Roller Bearing Units—Link-Belt Co., Indianapolis, Ind. Book No. 1494, 11 pages, 6x9 in. Catalog of anti-friction bearing units equipped with Shafer double row roller bearings. Outline drawings, dimension charts, and capacities are listed for pillow blocks, flanged units, take-up units, and hangers.

Super-Precision Ball Bearings for Spindles—Fafnir Bearing Co., New Britain, Conn. Six-page folder describing the application of precision ball bearings of the pre-loaded type to spindles. Because tolerances of 0.0002 in. or less are used in manufacture of the bearing, suggestions for precision fitting and mounting are given.

Tube Fabricating Equipment—Parker Appliance Co., Cleveland, Ohio. Bulletin No. 40, 24 pages, 8½x11 in. Bending and flaring equipment for tubing shown. Line drawings of all types of bends, a chart of radii for various sized tubing and numerous examples of bends are included.

Valves—Hancock Valve Div., Consolidated Ashcroft Hancock Co., Bridgeport, Conn. Bulletins No. 7011A, "Flocontrol" and "Union Bonnet Bronze Valves," 12 pages, 7¾x10½ in. Describing a straight-line control valve with micrometer adjustment with cut-away section photograph and flow charts with relative capacities. Also union bonnet bronze valves with stainless steel valve cone and disk.

Variable-Speed Drives—Reeves Pulley Co., Columbus, Ind. Booklet "Production Control for Your Machine Tools." 15 pages, 4x6 in. Pictorial and explanatory booklet showing a number of applications of variable-speed drives and pulleys to machine tools.

Variable-Speed Transmission—Link-Belt Co., 519 Holmes Ave., Indianapolis, Ind. Book No. 1574, 39 pages, 8½x11 in. Positive, infinitely variable speed, P.I.V. gear illustrated with photographs and line drawings to show the design principle. Various types of assemblies are shown with dimensioned outline drawings. Capacities for horizontal and vertical and motorized applications are included.

BOOKS AND BULLETINS

Principles of Physical Metallurgy

G. E. Doan. 314 pages, 6x9 in. 240 illustrations. Red clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $3.

This reference text is a revision and separate publication of Part III of "Principles of Metallurgy" by Liddell and Doan, reviewed in April 1934, page 158. As described in the previous review, this portion of the text, "explains the basic nature of metallic materials and their properties from an engineering point of view."

In revising this material for separate publication new chapters are included on unstable conditions, heat-treatment and commercial alloys. For the other chapters, the illustrations and treatment are the same as for the original text with the exception of a number of detail changes in the text matter. As a separate book, this text includes all the material of design interest that appeared in the larger book.

Strength of Materials

James E. Boyd. 548 pages, 6x9 in. 309 illustrations, 34 tables. Blue clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $3.75.

Although few changes have been made in the arrangement of this fourth edition, most of the problems are new. As in previous editions, the curves and photographs which accompany these data help to bridge the gap between theory and its application. Addition has been made to the discussion of indeterminate beams. The theorem of three moments includes beams which carry uniformly distributed loads or uniformly increasing loads over parts of the span, and beams for which supports are not in one plane. The tables and curves for the secant and Euler's formulas of the previous editions have been recalculated from the better values of the modulus of elasticity and yield point of structural steel, adopted by the Column Committee of the American Society of Civil Engineers. The chapter on working formulas for columns has been extended to include the parabolic formulas recommended by this committee and also equations for the columns made of aluminum alloys. The book is designed for use with the 1934 edition of the American Institute of Steel Construction Handbook or the 1934 edition of the Carnegie Pocket Companion.

Procedure Handbook of Arc Welding Design and Practice

The Lincoln Electric Co., Cleveland, Ohio. 596 pages, 5¼x9 in. 714 illustrations. Semi-flexible simulated leather covers. Price $1.50.

This third edition is enlarged 140 pages over the previous volume and contains American Welding Society specifications for filler metal; A.S.M.E. Boiler Code requirements for butt welds in heavy plate; hard facing of ferrous metals; procedures, speeds and costs for making all types of welds in sheet metal; examples of redesigning for arc welding and others. As the book has been written especially for the use of the engineer and designer, there is not one of the eight chapters which does not contain some data, photographs or procedure pertaining to his work.

Of special interest to the designer

of machinery is the 132-page chapter on "Designing for Arc Welded Steel Construction of Machinery," with line drawings and explanation of joining of structural members, the fabrication of levers, beds and bases, uprights and frames, and pulleys and gears. Another 132-page section on "Designing for Arc Welded Structures," will help designers of large structural members showing the comparison of arc-welded design to other types of joining. The last chapter of 135 pages has many photographs of typical applications. This handbook on arc welding procedure, design and practice is one book that the engineer cannot afford to be without.

Cast Metals Handbook

Handbook, 1935 Edition. 424 pages, 6¼x9¼ in. 130 illustrations, 125 tables. Red, semi-flexible cloth covers. American Foundrymen's Association, 222 West Adams St., Chicago, Ill. Price to non-members of A.F.A., $4.

This handbook is the first ever published, devoted exclusively to the properties and applications of cast materials. The objective of the book is "to present to engineers, designers and users of castings, condensed, authoritative and up-to-date data on cast metals. These data to be such as will enable the user to select the material best suited for his purpose and which will give him needed information to cooperae with foundries in obtaining his castings in the most satisfactory manner."

The book has eight sections among which are recommendations to designers of castings, one section each on the properties and applications of cast iron, malleable iron, steel and nonferrous metals, a cross-index and an advertising section. Included in the data of these sections are physical properties and constants, properties at room, elevated and subnormal temperatures, ranges of chemical composition, specifications, metallurgy, and testing methods. Considerable information also is given on cast materials for heat, corrosion and wear resistance. There are 126 tables of varied data. The illustrations include charts, graphs, line drawings, photographs and photomicrographs. Eight pages of bibliography with reference to 140 papers are included.

Metallography and Heat-Treatment of Iron and Steel

Albert Sauveur. 531 pages, 7½x10¾ in. 425 illustrations. Green clothboard covers. Published by McGraw-Hill Book Co., Inc. 330 West 42d St., New York, N. Y. Price $8.

When the first edition of this book made its appearance in 1912, it was the author's endeavor to compile a treatise on the metallography of iron and steel. Originally the book was intended for those seeking self-instruction in the art of metallography of ferrous metals, for teachers and students and for manufacturers and users of iron and steel. In the present fourth edition, 71 pages and 100 illustrations have been added since the first edition. Each chapter has been revised partially and several quite extensively, to incorporate the advances made in the last decade. Chapters 1 and 18 are newly added; the former entitled Metal Crystals and Their Atomic Structures, and the latter, A Simplified View of the Hardening of Steel, of the Transition Constituents and of Microstructure of Steel.

Believing that any student of metallography should have understanding of the underlying principles upon which the X-ray defraction analysis of metal rests, the author has supplied such data in a concise and simple manner. The aging of steel and nitriding have also been briefly described.

The book is divided into 28 chapters, among which are discussed in seven chapters pure and impure iron, wrought-iron and steel, and impurities in steel. The occurrence, causes and effects of the thermal critical point of iron and steel are discussed in three chapters. The mechanical treatment of steel and heat-treatment is contained in nine chapters. Several sections on various irons and alloy steels are included, and a section on photomicrography completes the book. A temperature conversion table from —459.4 deg. F. to 5,432 deg. F. is included.

Industrial Electronics

F. H. Gulliksen and *E. H. Vedder.* 239 pages, 6x9 in. 245 illustrations. Red clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $3.50.

Written to assist engineers in applying electronic equipment, the book succeeds well in presenting data on tubes and circuits, but falls short somewhat in showing the mechanical designer how to make use of the electronic devices.

Part I deals with the characteristics of various type of electronic tubes, including light-sensitive, high-vacuum and gas-filled types. Fundamental electronic circuits given in Part II include a number of applications of principal interest to the electrical designer.

In Part III, electronic instruments and controls are described under classifications of light-sensitive, indicating and recording, rectification and frequency converters, resistance welding controls, lighting controls and relays. Circuit diagrams, oscillograms and illustrations of complete devices accompany the electrical data. For regulators in Part IV, fundamentals of electrical design are given for voltage, speed, register, process and temperature regulation.

References to other books and technical publications are given at the end of each chapter. That most of these references are to electrical rather than to mechanical publications indicates the nature of the text matter. To many designers some confusion will probably result from the extensive use of Westinghouse trade names instead of descriptive terms for many of the electronic devices. In some instances, tubes or devices made by competitive companies are omitted entirely.

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Impact and Static Tensile Properties of Bolts

National Bureau of Standards, Research Paper R.P. 763, by H. L. Whittemore, G. W. Nusbaum, and E. O. Seaquist. 47 pages. Obtainable from Superintendent of Documents, Washington, D. C. Price 5 cents.

Report of the investigation to determine the properties of bolts under impact tensile and static tensile loading. Tests were made on 360 specimens of chromium-nickel steel, cold-rolled steel, monel metal, bronze, and brass bolts, ⅜, ½, ⅝ and ¾ in. diameter, having coarse and fine American Standard and also Dardelet threads. In all instances the "impact-works" for bolts having American National coarse threads were less than the impact-works for bolts of the same size and materials having American National fine threads. Similarly, the impact-works for bolts having Dardelet threads were much greater than the impact-works for bolts of the same size and material having National Standard coarse threads. The relations of the "static-works" and maximum static loads were similar to those for the impact-works. For bolts of the same size and having the same threads, the bolt efficiencies were approximately the same for all of the materials. Illustrated with 23 photographs and charts and 17 tables.

How Equipment Manufacturers Provide Against Inadequate Specifications in Customers' Orders

Metropolitan Life Insurance Co., 1 Madison Ave., New York, N. Y. Policyholders Service Bureau. Bulletin 418, 21 pages.

Results of a survey describing methods used by manufacturers, particularly machinery makers, to obtain the necessary details regarding customers' orders so that goods when shipped, will meet the customers' requirements. The report points out that the methods can be grouped in four general classes: (1) The direct contact method, through personal calls or correspondence, (2) the contract method, (3) the data sheet method, and (4) the "textbook" catalog method.

The report describes how these various methods are used, quoting directly from interviews with representative manufacturers. The third method is illustrated by four typical specimen data sheets that are currently used by the companies interviewed. The master parts list and octuple order form, each designed to prevent misinterpretation and error, are also reproduced.

Length of Material for 90-Deg. Forms—I

J. K. OLSEN

Formerly Chief Draftsman, Stewart Warner Company

TO GET the best results when bending or forming sheet metal, corner radii as large as possible should be specified. When a liberal radius is used, the grain structure is better arranged at the neutral line or arc where the bend is made. When the radius is formed, the stock on the outside of this neutral line expands or spreads out, while the stock on the inside of the neutral line is compressed or squeezed together. When a sharp corner or a very small inside radius is used, the neutral line is closer to the inside of the stock, so that the metal inside the neutral line must be squeezed into a very limited space. In this instance the metal outside the neutral line must be stretched unduly. In large radii bends, there is a more balanced condition since the stretching and squeezing of the metal is more uniform than in small radii bends.

Table I—Equations for X, Y and Developed Lengths

A in Deg.	X	Y	Developed Length
15	$3.732 \times B + 0.132 \times (R_1 + R_2)$	$3.864 \times B - 0.132 \times (R_1 + R_2)$	$3.864 \times B + 0.130 \times (R_1 + R_2)$
22½	$2.414 \times B + 0.199 \times (R_1 + R_2)$	$2.613 \times B - 0.199 \times (R_1 + R_2)$	$2.613 \times B + 0.194 \times (R_1 + R_2)$
30	$1.732 \times B + 0.268 \times (R_1 + R_2)$	$2.000 \times B - 0.268 \times (R_1 + R_2)$	$2.000 \times B + 0.256 \times (R_1 + R_2)$
45	$B + 0.414 \times (R_1 + R_2)$	$1.414 \times B - 0.414 \times (R_1 + R_2)$	$1.414 \times B + 0.371 \times (R_1 + R_2)$
60	$0.577 \times (B + R_1 + R_2)$	$1.155 \times B - 0.577 \times (R_1 + R_2)$	$1.155 \times B + 0.470 \times (R_1 + R_2)$
67½	$0.414 \times B + 0.668 \times (R_1 + R_2)$	$1.082 \times B - 0.668 \times (R_1 + R_2)$	$1.082 \times B + 0.510 \times (R_1 + R_2)$
75	$0.268 \times B + 0.767 \times (R_1 + R_2)$	$1.035 \times B - 0.767 \times (R_1 + R_2)$	$1.035 \times B + 0.542 \times (R_1 + R_2)$
90	$R_1 + R_2$	$B - R_1 - R_2$	$B + 0.571 \times (R_1 + R_2)$

When calculating the developed length of the bends, the stock thickness, inside radius of bend and hardness of material must be considered. For sharp corners or for radii up to one stock thickness, the neutral bending radius is ⅓ the thickness inside the stock from the inside edge of the bend. For radii of two or more stock thicknesses, the neutral radius is located in the center of the stock thickness. As there is an overlapping of constants when changing from ⅓ to ½ stock thickness, the neutral radius has been proportioned to obtain proper constants between 1 and 2 thickness factors.

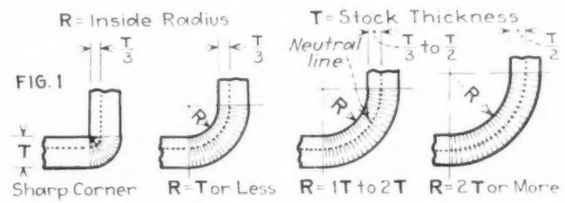
The developed length along the neutral line of 90-deg. bends is:

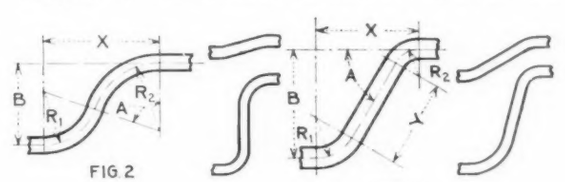
(a) For sharp corner or radius up to $1T$, the developed length $= R + (T/3) \times 1.5708$

(b) When radius is more than $2T$, the developed length $= R + (T/2) \times 1.5708$

The developed length along the neutral line of a bend of any angle is:

(c) For sharp corner or radius up to $1T$, the developed length $= R + (T/3) \times 0.01745 \times$ deg. in bend





(d) When radius is more than $2T$, the developed length $= R + (T/2) \times 0.01745 \times$ deg. in bend

In Fig. 1 is shown the location of the neutral bending line and how the stock is stretched and squeezed on either side of the neutral line.

In the chart on the following page, the developed lengths of the material for 90-deg. forms and bends are shown.

When the developed length of stock is required for a double bend in which the two neutral-line radii are tangent to each other it is desirous to know the value of X as in Fig. 2. When R_1, R_2 and B are known, solving for X,

$$X = \sqrt{2 \times B \times (R_1 + R_2 - B/2)}$$

If B and X are known, solving for $(R_1 + R_2)$; $R_1 + R_2 = (X^2 + B^2)/2B$

To find the developed length when R_1, R_2 and B are known, it is first necessary to find the value of angle A from the equation:

$$Cos\ A = \frac{R_1 + R_2 - B}{R_1 + R_2}$$

Developed length $= 0.01745 \times A \times (R_1 + R_2)$

When calculating dimensions X, Y and the developed length at the neutral line of a combination bend of any angle, A, B, R_1 and R_2 Fig. 3, are usually known. Table I gives equations for X, Y and developed lengths for various standard angles.

$$X = Cot\ A \times B + (R_1 + R_2) \times (cosec\ A - cot\ A)$$

$$Y = Cosec\ A \times B - (R_1 + R_2) \times (cosec\ A - cot\ A)$$

$$X + Y = B \times cot \frac{A}{2} \quad \text{(Optional formula)}$$

Developed length $= Y + 0.01745 \times A \times (R_1 + R_2)$

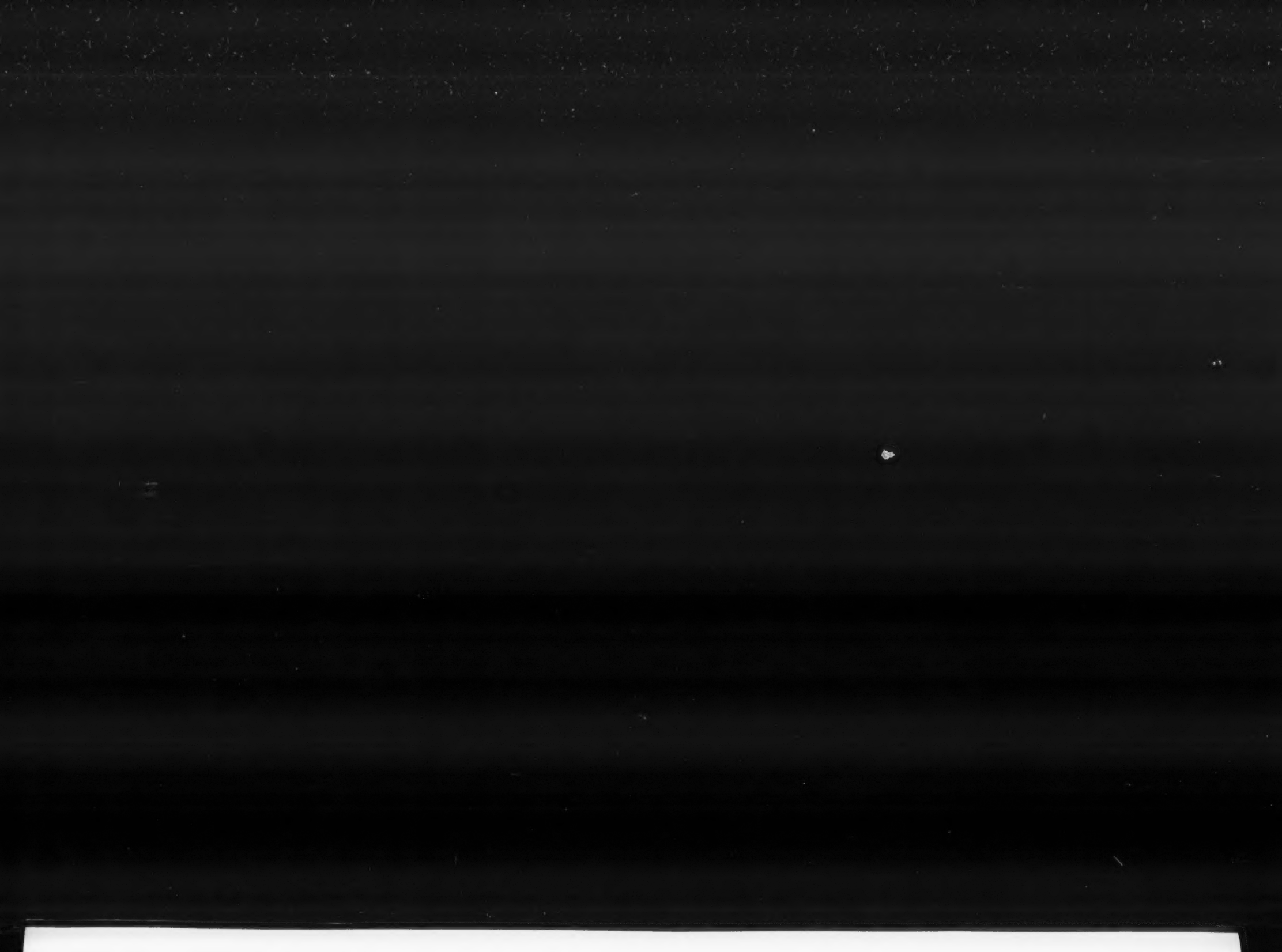
The accompanying chart will be followed in January by two others for 90-deg. forms for 5/32 to 6-in. radii.

Length of Material for 90-Deg. Forms—I

J. K. OLSEN
Formerly Chief Draftsman, Stewart Warner Company

Thickness of Material in Inches	Sharp Corner	DEVELOPED LENGTH IN INCHES Inside Radius of Form in Inches														
		.005R	.010R	1/64R	.020R	.025R	1/32R	.040R	3/64R	.050R	1/16R	5/64R	3/32R	.100R	7/64R	1/8R
.004	.002	.0105	.0188	.0276	.0346	.042	.052	.066	.0767	.0817	.101	.126	.150	.160	.1748	.1995
.005	.0026	.0108	.0196	.028	.035	.043	.0529	.0668	.077	.0825	.102	.1266	.151	.161	.1756	.200
.007	.0036	.0115	.020	.030	.0369	.0448	.0545	.068	.079	.084	.1037	.128	.1527	.1626	.177	.2018
.008	.0042	.012	.0206	.0305	.0377	.0456	.055	.069	.0798	.0848	.1045	.129	.1535	.163	.178	.2026
.010	.0052	.013	.0213	.031	.039	.047	.0569	.0707	.081	.086	.106	.1305	.155	.1649	.1795	.204
.012	.0063	.014	.022	.0316	.0396	.0486	.058	.072	.0829	.088	.1076	.132	.1566	.1665	.181	.2058
.014	.0073	.015	.0229	.032	.040	.049	.060	.0738	.0845	.0895	.109	.1337	.158	.168	.1827	.207
.0156	.0082	.016	.0239	.0325	.0407	.050	.061	.075	.0858	.0908	.110	.1349	.159	.169	.1839	.2086
.016	.0083	.016	.024	.0328	.041	.0508	.0616	.075	.086	.091	.1107	.135	.1598	.1696	.184	.2089
.018	.0094	.017	.025	.0339	.0418	.0515	.062	.077	.0877	.0927	.112	.1368	.161	.171	.1858	.2105
.020	.0105	.018	.026	.0349	.0425	.052	.0625	.0785	.089	.094	.1139	.138	.1629	.1728	.187	.212
.022	.0115	.019	.027	.036	.0429	.0525	.063	.079	.0907	.0958	.1155	.140	.1645	.174	.189	.2136
.025	.013	.0209	.0287	.0375	.0445	.053	.064	.0796	.0915	.098	.1178	.142	.1668	.1767	.191	.216
.028	.0146	.0225	.030	.039	.046	.0539	.0645	.0805	.092	.0988	.120	.1447	.169	.179	.1937	.218
.0312	.0163	.024	.032	.0408	.0478	.0556	.065	.081	.093	.0997	.1227	.147	.1717	.1816	.196	.2209
.032	.0167	.0245	.032	.041	.048	.0559	.0656	.0815	.094	.100	.123	.1477	.172	.182	.1968	.2215
.035	.0183	.026	.0339	.0427	.0496	.0575	.067	.082	.095	.1009	.124	.150	.1747	.1846	.199	.2238
.0375	.0196	.0275	.035	.044	.051	.0589	.0687	.0828	.096	.1015	.1245	.152	.1766	.1865	.201	.2258
.040	.0209	.0287	.0366	.045	.052	.060	.0699	.084	.0965	.102	.1255	.153	.1786	.1885	.203	.2278
.042	.022	.0298	.0377	.0465	.053	.061	.071	.0848	.097	.1026	.126	.1535	.180	.190	.2047	.229
.0437	.0229	.0306	.0385	.047	.054	.062	.072	.0856	.0977	.103	.1265	.1538	.1815	.191	.206	.2307
.045	.0236	.031	.039	.048	.055	.0628	.0726	.086	.0985	.1035	.127	.154	.1825	.192	.207	.2317
.049	.0256	.0335	.041	.050	.057	.0649	.0746	.088	.099	.1047	.128	.1545	.183	.1956	.210	.2348
.0508	.0265	.034	.042	.051	.058	.0658	.0756	.089	.100	.105	.1285	.155	.1836	.196	.2116	.236
.057	.0298	.0377	.0456	.054	.061	.069	.0789	.0927	.103	.108	.1295	.156	.1845	.1978	.214	.241
.058	.0304	.038	.046	.0548	.0617	.0696	.079	.093	.1038	.1088	.130	.1565	.185	.198	.2145	.2419
.0625	.0327	.0405	.048	.057	.064	.0719	.0817	.0955	.106	.111	.131	.1575	.186	.199	.216	.245
.064	.0335	.041	.049	.058	.0649	.0727	.0825	.096	.107	.112	.1316	.1585	.1868	.1997	.217	.2457
.065	.0340	.0418	.0496	.058	.065	.073	.0829	.0968	.107	.1125	.132	.159	.187	.200	.2175	.246
.072	.0377	.0456	.053	.062	.069	.077	.0867	.100	.111	.116	.1359	.161	.1885	.202	.220	.248
.078	.0408	.0487	.0565	.065	.072	.080	.0898	.1037	.114	.119	.139	.163	.190	.2038	.2225	.2495
.0808	.0423	.050	.058	.0668	.0737	.0815	.091	.105	.1158	.1208	.140	.1649	.191	.2047	.2235	.250
.083	.0434	.051	.059	.0677	.0748	.0826	.092	.106	.1167	.1218	.141	.1659	.192	.205	.225	.251
.0907	.0474	.055	.063	.0719	.0789	.0867	.096	.110	.121	.126	.1456	.170	.194	.207	.2265	.2535
.0937	.049	.0569	.0647	.0735	.080	.088	.098	.1118	.1225	.1275	.147	.1717	.1959	.2079	.227	.2549
.095	.0496	.0575	.065	.074	.081	.0889	.0986	.1125	.123	.128	.1478	.172	.1968	.2085	.2275	.2555
.1018	.0533	.0606	.0689	.0778	.0846	.092	.102	.116	.1268	.1317	.151	.1759	.200	.2099	.2295	.258
.109	.057	.0649	.0727	.0815	.088	.096	.106	.1199	.1305	.1356	.155	.1797	.204	.214	.2315	.261
.120	.0628	.0707	.0785	.087	.094	.102	.1118	.1257	.136	.141	.161	.1855	.210	.2199	.2345	.2645
.125	.0654	.073	.081	.0898	.0968	.1046	.114	.128	.1389	.144	.1635	.188	.2125	.222	.237	.267
.1406	.0735	.081	.089	.098	.1049	.1128	.1225	.136	.147	.152	.1717	.196	.2207	.2306	.245	.2697
.1562	.0817	.0895	.097	.106	.113	.121	.1307	.1445	.155	.160	.1799	.204	.2289	.2388	.253	.278
.1718	.0899	.0977	.1056	.114	.121	.129	.1389	.1527	.163	.168	.188	.2125	.237	.2469	.2615	.286
.1875	.0982	.106	.1139	.1227	.1296	.137	.147	.161	.1717	.1767	.196	.2209	.245	.255	.2699	.2945
.203	.1062	.114	.1219	.1307	.1376	.1455	.155	.169	.1797	.1847	.204	.2289	.253	.263	.2779	.3025
.2187	.1145	.122	.130	.139	.1459	.1538	.163	.177	.188	.193	.2127	.237	.2617	.2716	.286	.3109
.234	.1225	.130	.138	.147	.1539	.1618	.1715	.185	.196	.201	.2207	.245	.2697	.2796	.294	.3189
.250	.1308	.1387	.1466	.155	.162	.170	.1799	.1937	.204	.209	.229	.2535	.278	.2879	.3025	.327
.281	.1472	.1548	.162	.1717	.178	.1858	.196	.209	.2207	.225	.245	.2699	.294	.3036	.3189	.3435
.3125	.1635	.171	.179	.188	.1949	.2028	.2125	.226	.237	.242	.2617	.286	.3107	.3206	.335	.3599
.3437	.1799	.1877	.1956	.204	.211	.219	.2289	.2427	.253	.258	.278	.3025	.327	.3369	.3515	.376
.375	.1963	.204	.212	.2209	.2278	.2356	.245	.259	.2699	.2749	.2945	.319	.3435	.353	.368	.3927
.4375	.229	.2369	.2447	.2535	.260	.268	.278	.2919	.3025	.3076	.327	.3517	.376	.386	.4007	.425
.500	.2617	.2695	.277	.286	.293	.301	.3107	.3245	.335	.340	.3599	.384	.4089	.4188	.433	.458
.5625	.2945	.302	.310	.319	.3259	.3338	.3435	.357	.368	.373	.3927	.417	.4417	.4516	.466	.4909
.625	.3275	.335	.3429	.352	.3586	.3665	.3765	.390	.401	.4057	.4257	.450	.4747	.484	.499	.5239
.6875	.3599	.3677	.3756	.384	.391	.399	.4089	.4227	.433	.438	.458	.4825	.507	.517	.5316	.556
.7500	.3927	.400	.408	.417	.424	.432	.4417	.4555	.466	.471	.4909	.515	.5399	.5498	.564	.589
.8125	.4254	.433	.441	.4499	.4568	.4646	.474	.488	.4989	.5039	.5235	.548	.5726	.5825	.597	.6217
.875	.458	.465	.473	.4825	.489	.4968	.507	.520	.5316	.536	.556	.5807	.605	.6147	.6297	.654
.9375	.4909	.4987	.5066	.515	.522	.530	.5399	.5537	.564	.569	.589	.6136	.638	.648	.6626	.687
1.000	.5235	.531	.539	.548	.555	.5628	.5726	.586	.597	.602	.6217	.646	.6707	.6806	.695	.7199

PRODUCT ENGINEERING © REFERENCE BOOK SHEET



MODERN FASTENINGS

Feature MODERN METHODS MODERN ECONOMIES

A comparison of today's types of fastenings with those of a few years ago shows many a once-orthodox type gone by the board. Demands for lower costs and simplified fabrication have changed the picture.

To fill these demands, Scovill has done considerable development work in volume production of cold-headed fastenings. The illustration at the right shows the wide possibilities offered by this method. Some are made from brass, some from steel, others from bronze, copper and aluminum. Each was produced to meet the particular requirements of one manufacturer's product.

Scovill cold-headed and threaded products are today used in electrical devices, railway signal apparatus, automobiles and accessories, sewing machines, office machines, plumbing specialties, calendar pads, inserts for plastics, and so on through a list as wide as industry.

Substantial economies — both in the cost of the fastenings and in their later assembly — are frequently made through the use of Scovill's facilities for the production of this type of material. Redesigning of products is not necessarily a preliminary to these economies.

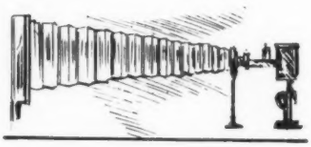
Scovill's Screw Products Division welcomes discussion with manufacturers interested in the application of modern fastenings to their products. A call or a letter to any Scovill office or to Scovill Manufacturing Company, 35 Mill Street, Waterbury, Connecticut, will bring further details of Scovill's scope along these and other metal-working lines.

SCOVILL

SCOVILL MANUFACTURING CO., WATERBURY, CONNECTICUT

Boston, Providence, New York, Philadelphia, Atlanta, Syracuse, Pittsburgh, Detroit, Chicago, Cincinnati, San Francisco, Los Angeles • IN EUROPE: The Hague, Holland • IN CANADA: 334 King Street, E., Toronto, Ontario

Microstructure of medium grain size nickel silver. Mag. 150X Etch—10% H_2SO_4 (Electrolytic)



The Grain Size of Riverside Nickel Silver is Controlled to Ensure Proper Drawing Qualities

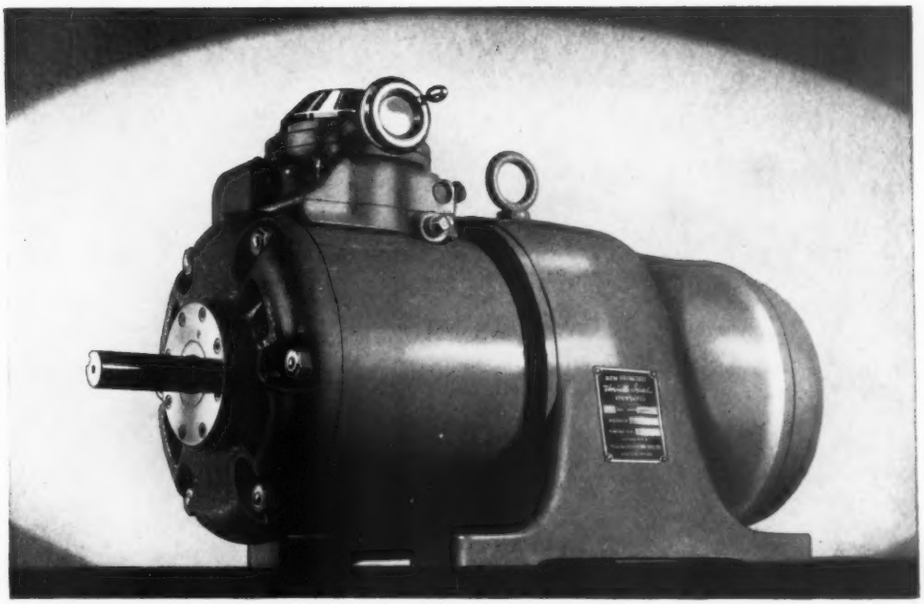
Articles or parts which are to be deep-drawn, spun or stamped, require a properly alloyed, soft, smooth-drawing Nickel Silver, ductile enough to "flow" to the contour of the tool, but sufficiently dense in structure to prevent strain, roughness, open grain, or orange peel effect detrimental to surface finishes. To supply a metal which must combine utmost ease of forming with a suitable surface for polishing or plating after fabrication, requires expert processing and a nicety of balance between deep-drawing quality and fine grain structure.

For these applications, Riverside Nickel Silver is produced under laboratory supervision to a controlled grain size, through micrographic determinations as to the best structure for a customer's individual needs.

The Riverside Metal Company has specialized in the production of wrought Nickel Silver since 1897. If you have a problem involving deep-drawing and surface finishing—or any other problems pertaining to the use of Nickel Silver—this Company can offer you expert assistance through experience data, productive and metallurgical facilities.

THE RIVERSIDE METAL COMPANY
RIVERSIDE *Burlington County* NEW JERSEY
NEW YORK • HARTFORD • CLEVELAND • CHICAGO

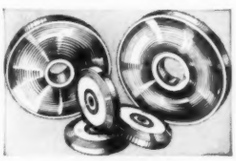
Riverside
NICKEL SILVER
SHEET · STRIP · WIRE · ROD



Thousands of Speeds
at the touch of a finger

Speed infinitely adjustable throughout entire range. Ratio, 6 to 1. Transmission and motor built as one compact, highly efficient unit.

Hardened steel rollers transmitting drive from constant speed input race to variable speed output race operate under torque - controlled contact pressure. Rollers inclined by operation of speed control roll themselves into required ratio position. Only finger touch required on control wheel.



RACES AND ROLLERS

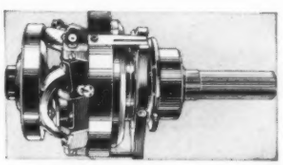
INCLINED ROLLER

Speeds may be pre-selected or adjusted while running.

With 1,750 r.p.m. motor, *any* speed from 600 to 3,600 r.p.m. immediately available. Built with 1,200 or 900 r.p.m. motors for correspondingly lower speeds.

Always starts from and stops in low-speed, high-torque position. . . . Avoids overloading motor.

Positive drive is assured under all conditions of loading, including rapid reversing or extreme overload.



RACE AND ROLLER ASSEMBLY

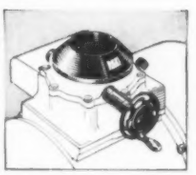
Unit is torque conscious. Automatic pressure device utilizes the imposed torque load to generate the required pressure between rollers and races. Pressure is always proportional to the input or output torque load—never exceeds requirements.

TORQUE FLANGE

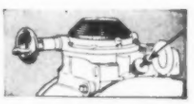
Revolving parts in positive rolling contact are inherently in balance, assuring exceptional quietness and freedom from vibration at all speeds.

No adjustments of any kind are ever required. New Departure Ball Bearings used throughout.

Outstanding ease of control . . . Speed changes obtained instantly either by handwheel on unit or remote control to suit any type of installation. Full automatic cam-operated control for speed changes occuring in variously timed cycles.



SPEED CONTROL



TIME CONTROL

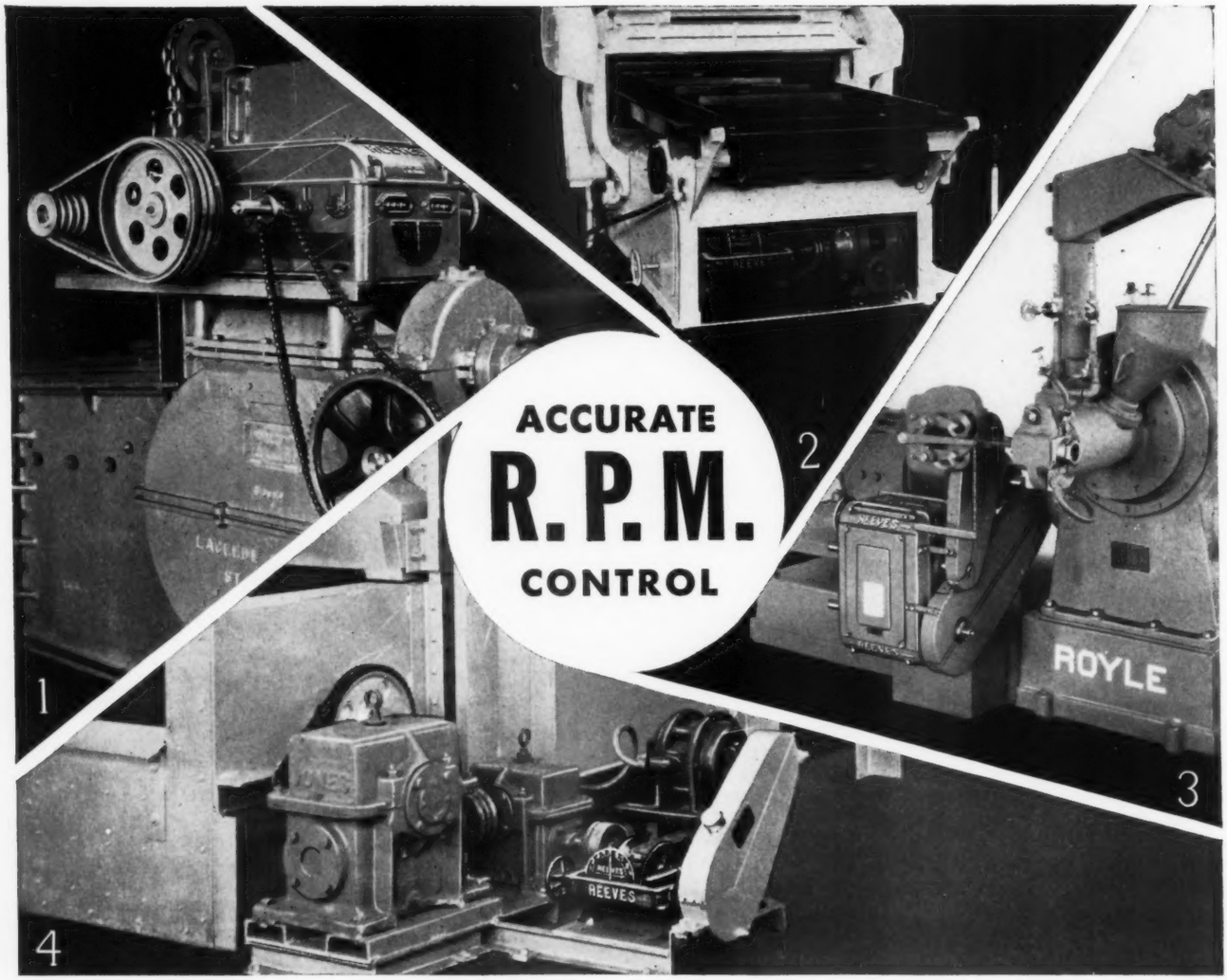
Time required for unit to shift up or down to any desired speed is readily adjustable. Minimum time, low to high or vice versa, three seconds.

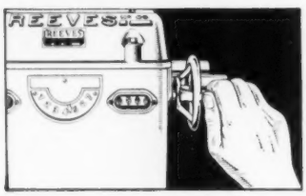
Unit adapted to mounting in any position — vertical, horizontal, sidewall or ceiling.

Send for catalog PE, giving detailed description.

The New Departure Manufacturing Company, Bristol, Connecticut.

NEW DEPARTURE *Variable Speed* TRANSITORQ





PICTURED above are four machines on which REEVES Variable Speed Transmissions are incorporated as standard equipment. These machines—selected as examples from over 1100 different makes which are standardly REEVES-equipped—illustrate the important operating advantages obtainable on any driven machine with REEVES Variable Speed Control.

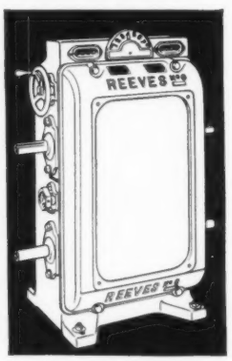
1. STOKER—Any rate of coal feed over a 4:1 ratio is available at the turn of a handwheel on this chain-grate stoker. This permits correct feeding according to grade of coal, BTU and any required steam pressure. Efficient combustion is always secured. Feeding is REEVES-regulated to fractional ounces per hour.

2. MEASURING KNIFE CAKE DEPOSITOR—Handles without damage to dough, the lightest angel food and the heaviest fruit cake, due to REEVES regulation. Note how compactly the REEVES drive and motor are incorporated in base of machine (panel removed to show installation).

3. WELDING ROD COATING MACHINE—Operator can vary feeding speed accurately according to different diameters and kinds of rods, consistency of compounds applied and sizes of dies.

4. HEAT TREATING FURNACE—Accurate control of heating time is provided for handling many different sizes, shapes and kinds of products. This is a traveling type furnace with conveyor regulated through a REEVES with individual motor drive.

To provide these important operating advantages on production machines, a variable speed unit must be infinitely adjustable over a wide range—must be selective to fractions of r.p.m.—must accurately maintain a desired speed *without* fluctuation—must deliver power efficiently—must be durable—must be available in a wide range of sizes, designs, speed ratios and controls. ALL these essential features are combined in REEVES Transmissions, and have been proved in 80,000 applications in 16,000 plants. In all leading industrial centers, there is a REEVES speed control engineer. He is at your service, without obligation. May he call on you?



REEVES PULLEY COMPANY · COLUMBUS, INDIANA

Send information on applying variable speed control for standard equipment, as contained in new Handbook 35 which describes the methods used by 1100 different machine builders. (12-35)

Name.....

Company.....

Address.....

Thank You!

1935 A BIGGER AND BETTER YEAR

It's been a great year for Morse. Thousands of customers, both new and old, have given Morse a generous share of their business during 1935. Throughout industry there has been a definite upturn in business—plants are being modernized, definite savings are being made in production costs and Morse is endeavoring to meet these demands through careful, considerate service to industry.

Morse is also keeping pace with modernization with new equipment at both Ithaca and Detroit plants. These increased facilities assure Morse customers of better service in manufacturing and delivery.

Morse takes this opportunity to thank industry for making 1935 a bigger and better year, and also to show its appreciation of the sincere and earnest efforts of these Morse men in the field. With thorough knowledge and experience in transmission of power, they are always ready to serve industry with better methods of power transmission.

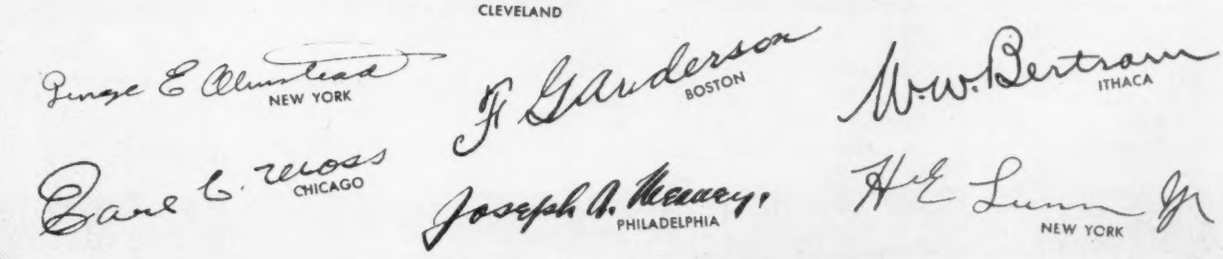
MORSE

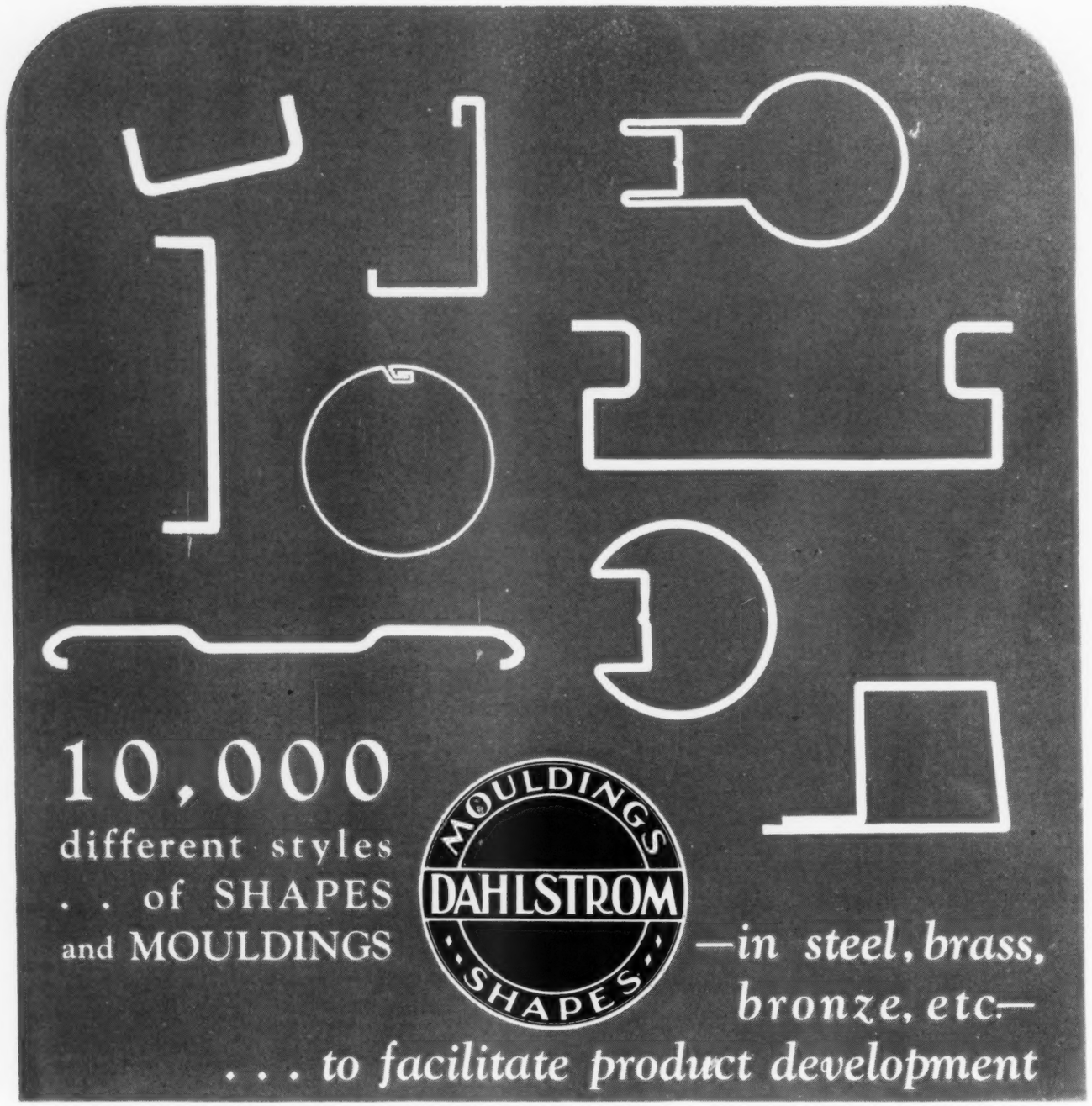
Silent and Roller Chains and Sprockets
Flexible Couplings and Clutches

Morse Magic Silent Chain Drive Selector automatically selects the proper drive, checks and designs chain drives, saves time. Send for one. It's free.

Morse 1936 Calendars are now ready. Ask for your copy.

MORSE CHAIN CO., ITHACA, N. Y.
Division of Borg-Warner Corporation





Dahlstrom offers a fabricating service in Shapes and Mouldings which is practically unlimited in scope.

Approximately $1,000,000 is invested in dies, rolls and press shapes for making more than 10,000 different styles of rolled mouldings and pressed shapes in steel, bronze, brass and other materials. Special shapes can also be furnished to meet specific and exacting requirements.

Dahlstrom Mouldings are fabricated from highest quality cold-rolled strip and sheet metals, are smooth in surface, exact in profile, light in weight and because of special treatment are very rigid.

In view of the outstanding savings in product design which are available through the use of Dahlstrom Metal Shapes and Mouldings, you will find it economical and profitable to consult our engineers relative to cutting the manufacturing cost of your products through Dahlstrom service.

Write for a copy of our catalog which gives a comprehensive idea of the many different shapes we are prepared to furnish.

DAHLSTROM METALLIC DOOR CO.
JAMESTOWN, N. Y.
Representatives in Principal Cities

SAVE WITH DAHLSTROM METAL SHAPES AND MOULDINGS

STRONG · TOUGH · ACCURATE

● The illustration indicates only partially the scope and the character of pressings that are now available in Alcoa Aluminum.

Consider the advantages of this process:

It utilizes the strong wrought alloys of Alcoa Aluminum, which weigh about one-third as much as the heavy metals.

The process itself, familiar to all engineers, lends superior mechanical properties, uniformity of structure. Pressings make possible a more nearly perfect distribution of metal, often showing considerable weight savings as compared for example with stampings. Also bosses, lugs, ears, hubs and similar details may be included in the design, thus saving assembly costs.

The surfaces of Alcoa Aluminum pressings are inherently smooth, and uniform in texture.

In many cases such close tolerances can be obtained that much of the machining and finishing required on such parts made by other processes can be completely eliminated.

The famous Alumilite* finish may be satisfactorily applied. Excellent results are obtained by polishing, etching, or widely used methods of finishing Aluminum.

We are ready to serve you, with quantity production facilities, under experienced supervision. Ask us to quote on your next part. We feel certain we can show you some interesting economies.

ALUMINUM COMPANY OF AMERICA, 1893 Gulf Building, Pittsburgh, Pennsylvania.

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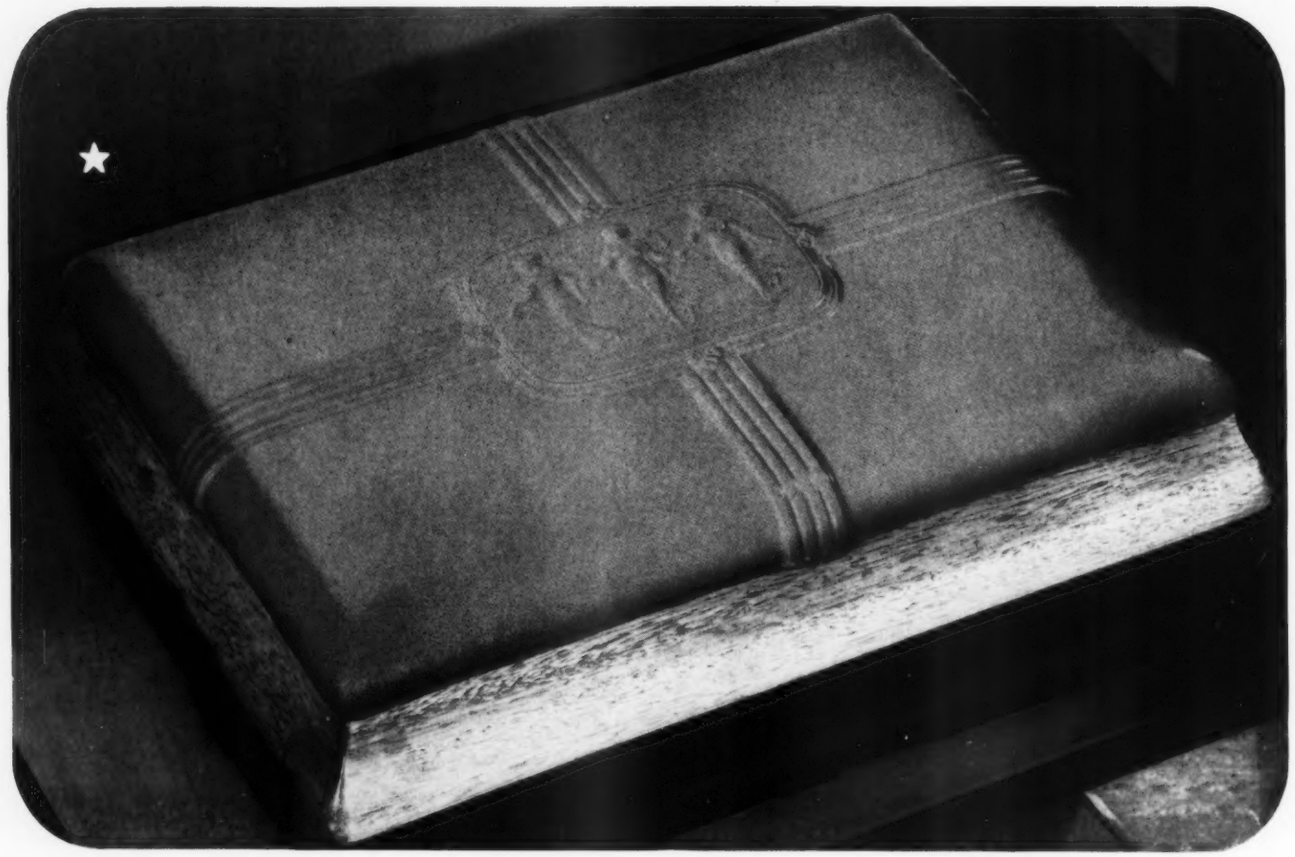
ALCOA · ALUMINUM

MOLDED COLOR



1ST FROM THE BERYLLIUM COPPER MOLD

Pictured above is the Cameo Silver Chest. Its brilliant Plaskon cover is product No. 1 from the beryllium copper mold... a Gorham Company development about which product engineers should know.

The intricate patterns and irregular contours of decorative items have not always been easily reproduced in the plastics. A steel die is ordinarily the ideal mold in which to make plastic goods. But unless carefully worked over, the steel mold gives only fair reproduction of the figured surfaces common to grilles, containers, trays, etc.

The new cast beryllium copper mold affords wider design possibilities and simplified manufacture for such plastic articles. Where ornamentation is the keynote of design, and where visual effect rather than exact dimensional accuracy is sought, it can be used to great advantage.

PLASKON stands available for these applications, and for every use to which urea plastics are put. The selection of MOLDED COLOR for the Cameo Cover bespeaks its high favor among designers and engineers. PLASKON quality and color beauty are helping hundreds of products in today's markets. There is every reason for you to inquire how it may help yours.

★

The Cameo Cover is molded for the Alvin Corporation by Associated Attleboro Manufacturers.

TOLEDO SYNTHETIC PRODUCTS, INCORPORATED · TOLEDO · OHIO

★ PLASKON ★

REDESIGN with PLASTICS

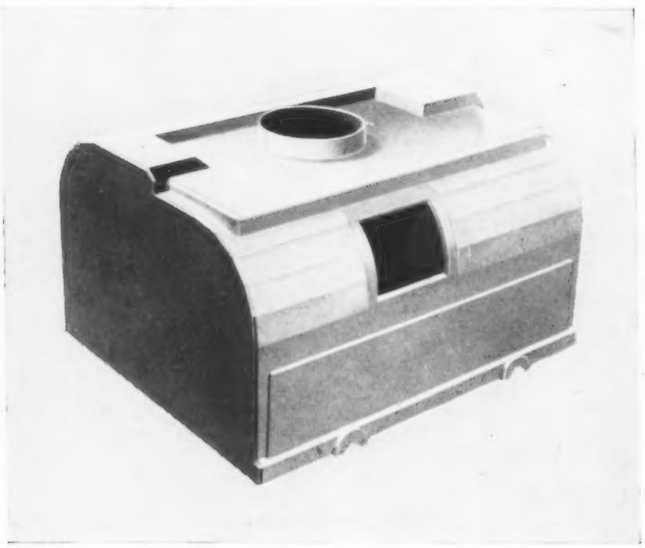
Simplified Design ★ **Extra Profits** ★ **New Appeal**

GILBERT and BARKER

CORRECT measurement is assured by the new Calco-Meter, manufactured by Gilbert and Barker, Springfield, Mass., because of the use of a TEXTOLITE valve plate. This plate holds a uniform seal on the sliding valves, providing true volume measure.

The composition of TEXTOLITE prevents scoring or excessive wear of the slide valves, and eliminates accumulation of residue on the valve faces. By lasting more than three times as long as nonferrous metal plates, TEXTOLITE gives longer life.

You obtain these advantages when you use TEXTOLITE for parts which require accurate molding and permanence of qualities.



TOLEDO SCALE

THE Toledo Scale Company, Toledo, Ohio, has recently announced an outstanding advance in scale design—the new Toledo Plaskon Duplex Scale. General Electric is proud to have contributed a part to this triumph in modern design by molding the white Plaskon scale case—the largest commercial plastics form ever molded for industry.

Without sacrifice of strength, Toledo was able to dress up its new scale with a strong, lightweight, attractive casing having a permanent, white, lustrous finish. There is no marring of the surface by chipping, because Plaskon is white all the way through.

The General Electric Plastics Department offers you the same opportunities for utilizing the many advantages of Textolite and Plaskon. There is a grade which has the particular properties that your product requires. Get in touch with the plastics specialist in the nearest G-E office. He will gladly assist you in selecting the right grade of Textolite or Plaskon for your requirements. Ask for a copy of "General Electric Complete Molding Service." Plastics Department, General Electric Company, West Lynn, Mass.

943-55

GENERAL ELECTRIC

FOR INCREASED SALES VOLUME—

Choose Color for a Good Start

Choose Hilo Clix for a Good Finish

HILO

In the face of closer competition and a flood of new products on the market, leading manufacturers are using the proven appeal of color to help increase their sales volumes and to attract new customers. The Right Color Plan makes a product easier to see, easier to remember and, above all, easier to sell.

Hilo makes Colors in a wide variety of Finishes from which you can choose the one best suited to your finishing requirements. For beauty, protection and speedy production we recommend—

HILO CLIX

Quick Baking Synthetic

Here is a finish which combines maximum surface hardness with minimum baking time — a boon to quick production schedules. A Hilo Clix Finish adds to the quality and attractiveness of the article. In bright, entrancing colors, it's "tops" in sales appeal.

Clix closely resembles porcelain in appearance. Its adherence to wood and metal is exceptional. It may be applied by brushing, spraying or dipping.

Write for color chart, specimen and liquid samples. Better yet, send us also your own specimen to finish — we'll be happy to return it in its Clix Finish — of course, with no obligation to you. See Clix in one of the brilliant, quick-selling colors—you'll like it.

HILO VARNISH CORPORATION

70 Years' Experience in Better-the-Finish

42-60 Stewart Avenue, Brooklyn, New York

Branches: Chicago Boston Philadelphia

Better..because THEY'RE WELDED

● Modern stainless steel barrels are *better because they're welded!* Welding assures strong, seamless, leakproof containers which are easy to clean and afford no place for bacteria to develop. These inherent features of jointless design and fabrication by welding, together with the natural resistance of stainless steel to chemical attack make sure that nothing will effect the contents of the barrel.

Welding has made many good products better—stainless steel barrels, refrigerators, automobiles, radios, streamlined locomotives, metal furniture, and a thousand other things. You, too, may find it profitable to consider the advantages in both production and sales which can be gained for your product by jointless design-for-welding.

Linde engineers will gladly cooperate with you in the design or redesign of your products for welding. The benefit of their broad experience is available from Linde Sales Offices located in thirty principal cities throughout the country and at 30 East 42nd Street, New York, N. Y.

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation

LINDE OXYGEN UCC UNION CARBIDE
PREST-O-LITE DISSOLVED ACETYLENE
OXWELD WELDING AND CUTTING APPARATUS AND SUPPLIES

- CRUCIBLES
- HEAT TREATING BOXES
- PLATING ANODE SUPPORTS
- THREADED PARTS
- THRUST BEARINGS
- STEAM TURBINE PACKING
- SLEEVE BEARINGS
- VACUUM TUBE ANODES AND GRIDS
- CONTACTS
- NOZZLES FOR CORROSIVE LIQUIDS
- METAL MOLDS
- RHEOSTAT DISCS
- TELEPHONE TRANSMITTER PARTS

USE CARBON OR GRAPHITE

The peculiar physical and chemical properties of CARBON—in either amorphous or graphitic form—make it applicable to many uses in Electrical, Mechanical, Thermal and Chemical equipment, for which no other material is available or equally well adapted.

CARBON and Graphite products can be manufactured in a great variety of shapes, a few of which are illustrated on this page. Carbon and Graphite products can be readily machined to meet the specific requirements of the application. Carbon is a good conductor of electricity.

CARBON IS INFUSIBLE

Carbon, in graphitic form, possesses excellent lubricating properties. Carbon is highly resistant to the action of most acids, alkalies and corrosive materials. Carbon may be used under oxidizing conditions at temperatures up to 400° C.

NATIONAL CARBON COMPANY, INC., HAS SPECIALIZED IN THE MANUFACTURE OF CARBON PRODUCTS FOR EVERY TYPE OF INDUSTRIAL APPLICATION.

- *Write for information on the application of Carbon or Graphite to your problems.*

AVERAGE PHYSICAL CHARACTERISTICS OF CARBON AND GRAPHITE PRODUCTS

Many of these properties can be modified over a considerable range to meet special requirements.

Characteristics	Coke Base Carbon	Electric Furnace Graphite
Electrical Resistance—Ohms /In.^{3}	.0014 - .0018	.0003 - .0005
Tensile Strength—Lbs./Sq. In.	600 - 1200	700 - 1200
Crushing Strength—Lbs./Sq. In.	6000 - 9000	3000 - 4000
Transverse Strength—Lbs./Sq. In.	3200 - 6000	3000 - 5000
Specific Gravity	2.0 - 2.1	2.20 - 2.24
Apparent Density—Gm./Cm.^{3}	1.53 - 1.64	1.53 - 1.70
Porosity—Per Cent	23 - 25	27 - 30
Specific Heat—Gm. cal./Gm.	.199 (26-538° C.)	.234 (26-538° C.)
Thermal Conductivity—20-40° C.	.0079	.057
Gm. cal./sec./cm^3/°C. 40-340° C.	.016	.41
Coef. of Thermal Expansion per ° C.	1.4-1.8 (x10^{-6})	0.8-2.0 (x10^{-6})
Volatilizing Temperature—° C.	3665	3665

NATIONAL CARBON COMPANY, INC.
Carbon Sales Division, Cleveland, Ohio
Unit of Union Carbide UCC and Carbon Corporation
Branch Sales Offices:
New York • Pittsburgh • Chicago • San Francisco

50,000 R.P.M.

in Daily Service

For almost twenty-five years NORMA-HOFFMANN have been preeminently HIGH-SPEED PRECISION Bearings. They have long been operating successfully, in day-after-day duty, at speeds up to 50,000 R. P. M. Nor is this quality confined to one particular PRECISION type. Research has developed a "Super-Speed" PRECISION Bearing for every purpose.

"LITRO" DEEP-GROOVE TYPE "CL"

For Thrust In Either Direction

This is the latest addition to the PRECISION "Super-Speed" line—a deep-groove type with uniform race shoulders, adapted to thrust in either direction. The lightweight, machined, balanced retainer is of specially-treated, hard, phenol-impregnated linen fabric, and rides on the ground shoulders (lands) of the inner ring. PRECISION in every minute detail adapts the "CL" Bearing to the highest speeds.

FIVE OTHER SUPER-SPEED BALL BEARINGS

LITRO "L" TYPE:—in both open (separable) and closed (side-assembled) types; machined, balanced, one-piece, land-riding, phenol-impregnated fabric retainer; adapted to thrust in one direction.

STANDARD OPEN TYPE:—a separablebearing with lightweight, one-piece, balanced, bronze retainer of channel section; for thrust in one direction only.

SUPRA "5" TYPE:—an open (separable) bearing with machined, balanced, one-piece, land-riding, bronze retainer, with oil grooves; for thrust in one direction.

DEEP-GROOVE SINGLE-ROW TYPE:—with special sturdy, pressed bronze ball retainer; adapted for thrust in either direction.

DEEP-GROOVE SINGLE-ROW TYPE:—with machined, balanced, solid, land-riding bronze retainer; adapted to thrust in either direction.

Write for Catalog

"NORMA-HOFFMANN"

PRECISION BEARINGS

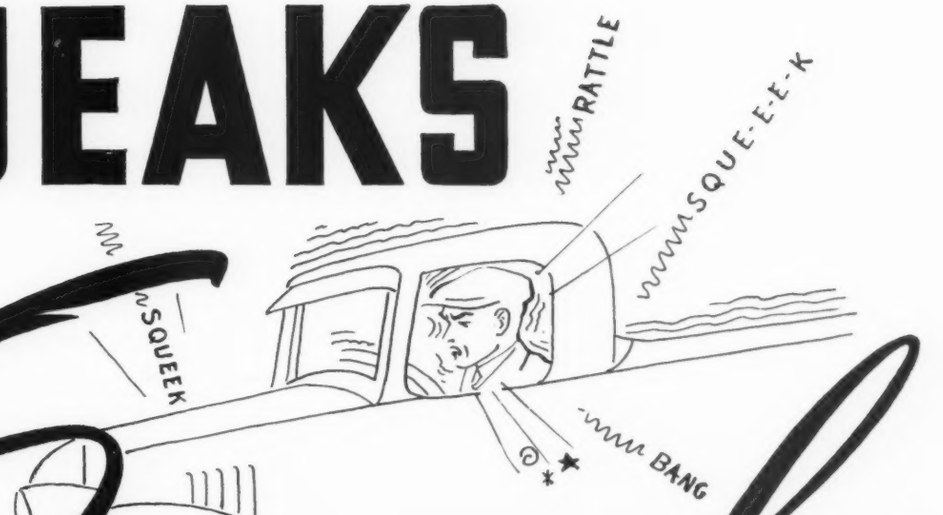
BALL, ROLLER AND THRUST

NORMA-HOFFMANN BEARINGS CORPORATION, STAMFORD, CONN., U. S. A.

You'll find Timken Bearings on the really tough jobs everywhere.... As a spectacular example: In this giant Natco drilling machine—552 Timken Bearings are used.... Running 132 drilling and countersinking operations on each automobile cylinder block with each cycle of the machine at the rate of 85 blocks per hour gives you an idea of the necessity of unfailing accuracy, economy and dependability which in no small measure are supplied by Timken Bearings.... Exacting installations of this character must indicate to you the advisability of insisting on and getting Timken Bearings when buying automobiles, motor trucks and any type of railroad or industrial equipment. The Timken Roller Bearing Company, Canton, Ohio.

Copyright 1935 by The Timken Roller Bearing Co.

SQUEAKS MEAN *Squawks*



ONLY A SPRING WASHER HAS *Live Action* TO COMPENSATE FOR WEAR AND LOOSENESS . . .

Spring Washers keep machinery tight and smooth-running in spite of wear and vibration. By compensating for play and looseness, they prevent squeaks and rattles. Their exclusive feature . . . *Live Action* . . . eliminates customer "squawks."

SPRING WASHER INDUSTRY

ONLY A SPRING WASHER HAS *Live Action!*

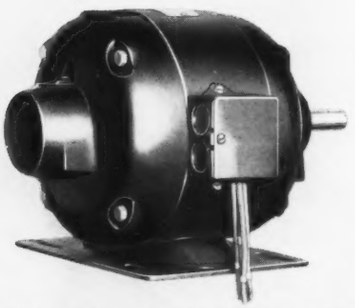
WHICH FRACTIONAL-HORSEPOWER MOTOR FOR POLYPHASE POWER SUPPLY ?

THE G-E POLYPHASE MOTOR, TYPE K, FOR GENERAL APPLICATIONS

For all-round use. A thoroughly dependable squirrel-cage motor that will give years of reliable service. Mounting dimensions are interchangeable with those of single-phase motors

THIS sturdy motor is available in a variety of mechanical modifications (as, for example, some of the types illustrated above) which will meet the power requirements of your design. Its ratings, from 1/8 to 3/4 hp inclusive, offer you a wide range from which to choose. Whether you require a standard or a special fractional-horsepower motor, General Electric has a type that will correctly meet your needs.

The Type K motor for polyphase power supply is but one of the large variety of G-E fractional-horsepower motors. It is a thoroughly dependable squirrel-cage motor that will give years of reliable service. Mounting dimensions interchangeable with those of other G-E fractional-horsepower motors assure you maximum value. For further information, communicate with General Electric Company, Schenectady, N. Y.



A totally enclosed motor that is protected against dust, dirt, mild chemicals, and moisture. A motor which has a long, carefree life

A gear-motor for low-speed requirements. It offers you unusual economies in installation and operating costs. Ready for direct connection to your machine

For stop-and-start applications, such as hoist, door operators, and other applications where a brake is required, this equipment will give you long service life and simplify installation

070-100

GENERAL ELECTRIC

Cross-Section of Typical Anaconda Extruded Shapes

ANACONDA *EXTRUDED SHAPES* to cut production costs

Countless brass parts are being made from as many different Anaconda Extruded Shapes by manufacturers of a wide range of products. Some have effected *amazing savings* with this type of stock. Perhaps you can, too.

We will welcome the opportunity of discussing with you the cost advantages and design possibilities of extruded shapes.

ANACONDA
from mine to consumer

THE AMERICAN BRASS COMPANY
General Offices: Waterbury, Connecticut
Offices and Agencies in Principal Cities

ANACONDA COPPER & BRASS

Adding RUST-PROOFING *to heavy machine parts*

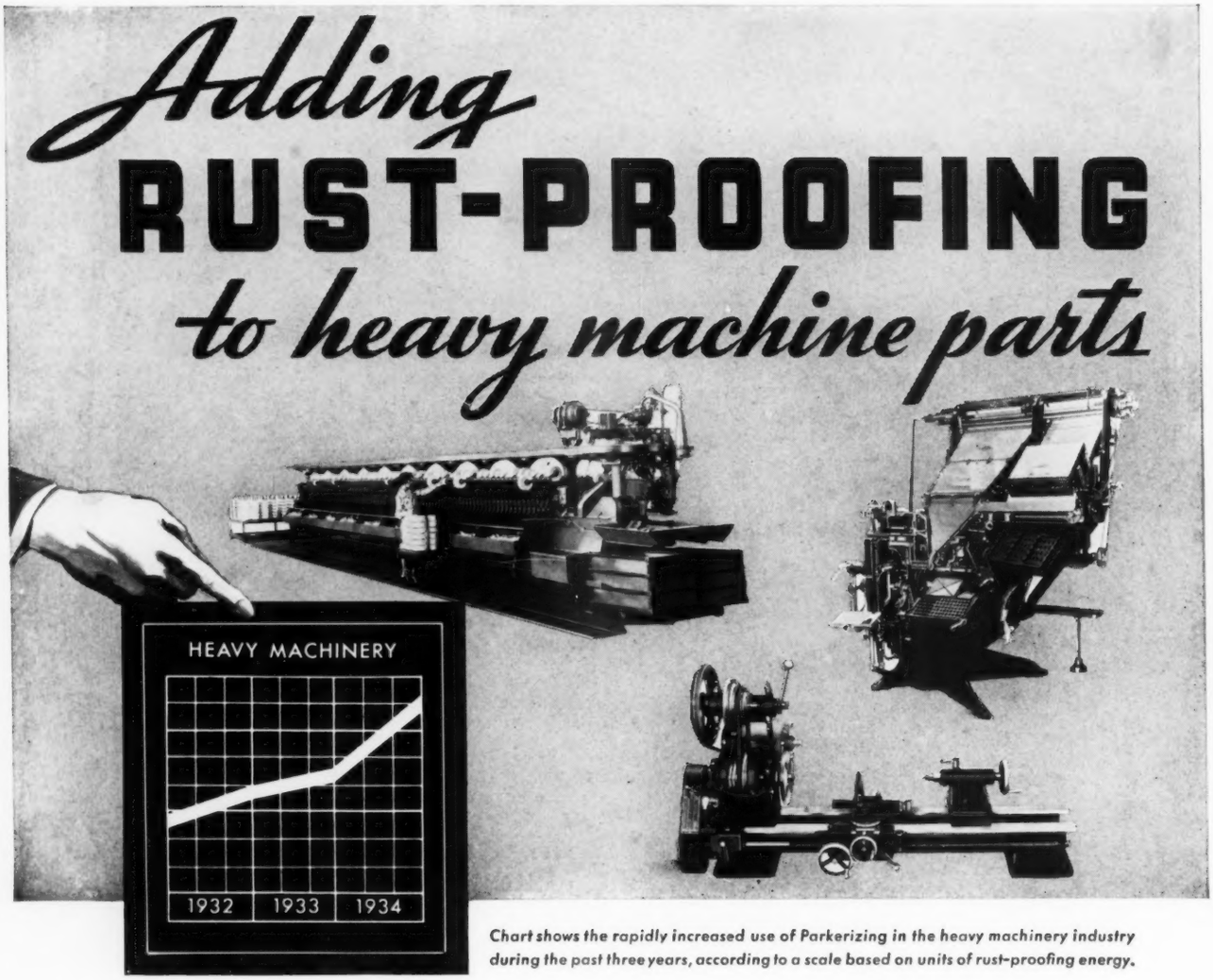


Chart shows the rapidly increased use of Parkerizing in the heavy machinery industry during the past three years, according to a scale based on units of rust-proofing energy.

FROM the tiny screw or bolt that assembles precision parts to big castings, Parkerizing plays an important part on heavy machines.

Rust is fatal to perfect operation and makes maintenance costly. That is why more than 600 parts of the best known linotype are Parkerized. It is equally reliable and efficient on the fine machines of many other industries. It is especially popular on this type of equipment because it is both rust-proofing and a finish. The Parkerized part needs no additional finishing treatment.

Parkerizing is one of the best known metal finishing methods and as such is a sales asset to the manufacturer who applies it.

PARKER RUST-PROOF COMPANY • 2179 E. Milwaukee Ave., Detroit, Michigan

For more than 20 years this company has devoted its entire time, talent and energy to the improvement of rust-proofing methods. A new book describing Parkerizing is available to manufacturers and technical men. Send for your copy.

PARKER
RUST-PROOFING
processes
BONDERIZING • PARKERIZING

Sinbad's Burden

. . . Yielding to the pleadings of the Old Man of the Sea, Sinbad lifted him onto his shoulders and carried him tenderly across the stream. To his amazement, the Old Man refused to alight. Instead, he entwined his legs so tightly around Sinbad's chest that he could not be shaken off. Day after day Sinbad's burden became more and more crushing. . . .

A MATERIAL, process or modus operandi will sometimes so firmly imbed itself in the construction of an implement, appliance, engine, machine, vehicle, or part, that discarding it in favor of something more modern is often difficult. Meantime, its continued use may become a serious burden to both production and sales departments. . . . For competition is ever ready to capitalize a rival's lack of progressiveness.

Is the persistent retention of once modern steels threatening to leave your company behind in the face of the newer discoveries of metallurgists and steel-makers? Have you brought yourself up to date on the latest progress of Molybdenum — the alloy which not only improves ordinary carbon steel, but actually increases the effectiveness of other alloys?

Greater strength, toughness and shock resistance, less temper embrittlement, easier machinability and welding — these are some of the qualities "Moly" imparts to steel and iron. Yet so powerful is Moly, and so little is the quantity required, that it seldom adds to — and generally reduces — the ultimate cost . . . because it usually lowers the first cost in alloy content, means fewer rejects and effects other shop economies.

Investigate Moly. Moly has had more than a decade of countless laboratory, steel-furnace, foundry, forge and punishing service tests. We invite engineers, metallurgists, production and business executives to write for either or both of these interesting books: "Molybdenum in 1934" and "Molybdenum in Cast Iron — 1934 Supplement." Also ask us to mail you our periodical news-sheet, "The Moly Matrix." Be free, too, to enlist the aid of our Detroit experimental laboratory. Climax Molybdenum Company, 500 Fifth Avenue, New York.

MOLY

CLIMAX Mo-lyb-den-um

INDUSTRY'S MOST MODERN AND VERSATILE ALLOY

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● You're looking into the business end of a centerless grinding machine in Illinois' Alloy Department.

Operating in a special air-conditioned room, this machine grinds to an oil-smooth finish with a tolerance of only one-half of one-thousandth of an inch. For beauty and accuracy of finish, this is truly the jewelry of the steel industry.

Alloy steel thus finished may be used without further polishing or lapping in many installations where accurate bearing surfaces are required.

Write for further information on these and other finishes now available in Illinois Alloy Steel products.

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United States Steel Corporation Subsidiary

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The smoother running, carefree, power saving advantages of Hyatts are well known in every field they serve. And of equal importance is the ability of Hyatt Roller Bearings to prolong their own life as well as the life of related parts. That's why there are more and more Hyatts used in the vital operating parts of equipment . . . The equipment builder's pledge of better design and the user's assurance of better operation. Hyatt Roller Bearing Company, Newark, Detroit, Chicago, Pittsburgh, San Francisco.

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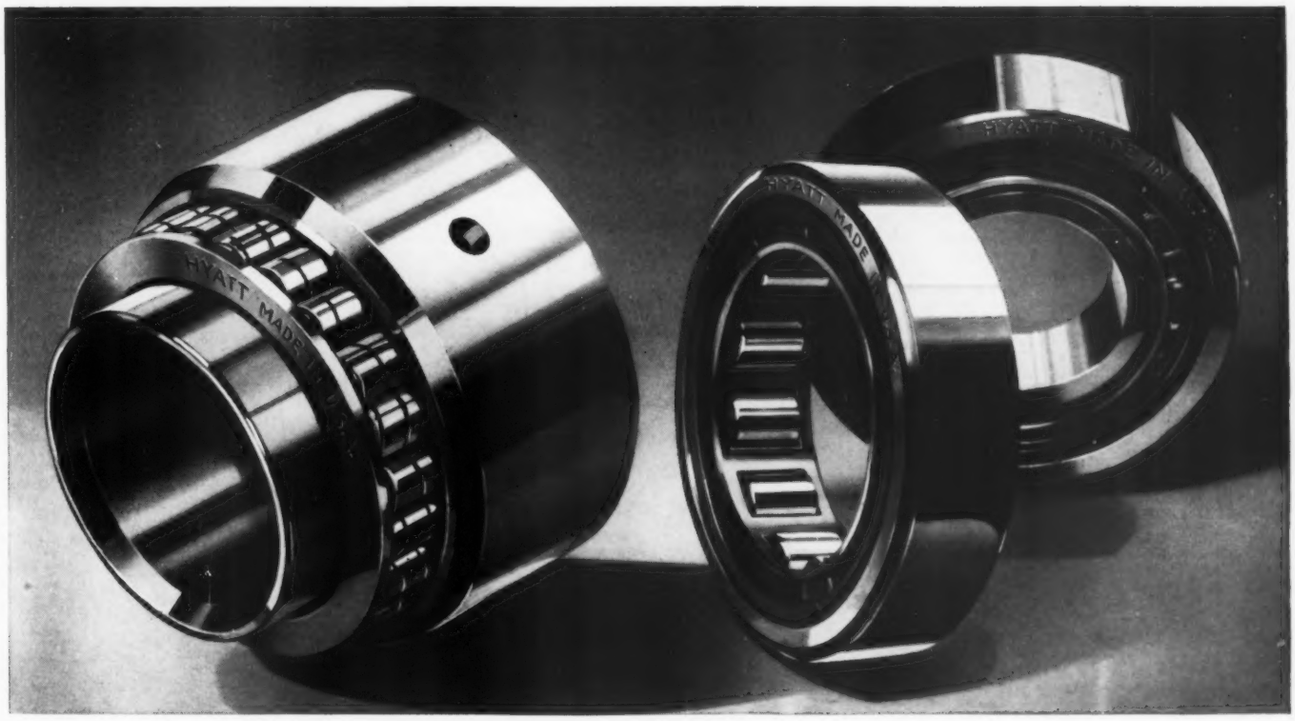
ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS



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and its accomplishments

15 Years specialized experience in designing and producing the finer motors exclusively.

15 Years steady growth of the company due to its high quality standard, its fair prices and square dealings with its customers.

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Latest Bulletins containing complete Technical Data on motors, specifications and other helpful information, sent upon request.

The* BALDOR *Line Includes:

SINGLE PHASE—Repulsion Induction	1/8 to 7½ H. P.
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Split Phase	1/30 to 1/3 H. P.
DIRECT CURRENT	1/8 to 3 H. P.
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Standard Horizontal and Vertical Motors for all applications. Ball Bearings in all sizes. Sleeve bearing up to 2 H. P.

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BALDOR
A BETTER MOTOR

ALLEN
COLD-DRAWN
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HOLLOW SCREWS

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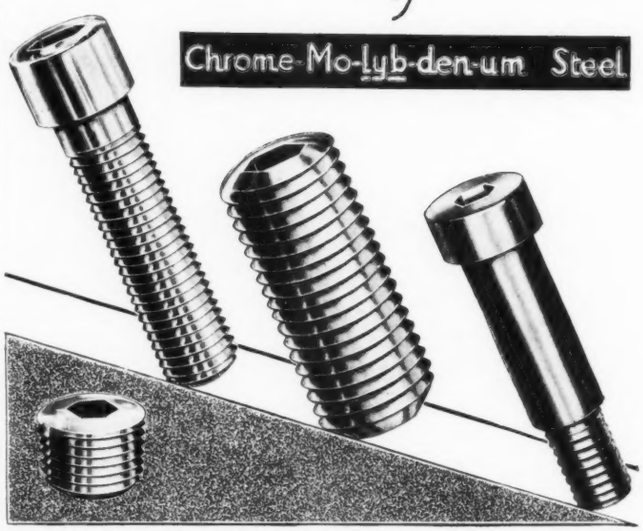

THEY HOLD TOGETHER the most versatile assemblies of new machines, machine tools and mechanical appliances on the show-floors today.

A large majority of exhibited new machines are equipped with ALLEN Hollow Set Screws, Hollow Head Cap Screws — emphasizing the trend in modern design; the types of equipment which make continued progress certain.

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LABORATORY TESTED
To Meet Standard Specifications

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"FATIGUE" RESISTANT

FREE CUTTING

BACK of every shipment of Seymour Phosphor Bronze is the thorough work of our well-equipped laboratory. Strict compliance with standard specifications, and with a customer's individual needs, is made a certainty in Seymour Phosphor Bronze by careful, scientific check from melt to final inspection.

In the casting department each heat is numbered and sampled. If satisfactory, the batch proceeds on its way. During its journey frequent tests are made in the laboratory, where hardness, tensile strength, elongation, ductility, grain structure — all important properties — are accurately determined. If at any stage the sample fails to meet the requirements set for the order, the batch is located by its heat number and promptly withdrawn. Any program less rigorous would endanger a standard of uniformity which is a fixed ideal in the Seymour plant.

If you would like to know how Seymour Phosphor Bronze will meet your needs, we will gladly supply samples for test purposes.

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Robbins & Myers MOTORS 1896 . . 1936

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Forty years ago, when the first electrical appliances were being developed for the home, store and office, Robbins & Myers began building motors to power these devices. They were good motors—so good that many of these 30- or 40-year-old motors are still in service.

R&M motors today have that same reliability, plus all the refinements that have resulted from 40 years of research and development. New slot combinations, mechanical modifications and resilient mounting that insure quiet operation, dynamically balanced running parts, and improved ventilation and lubrication are a few new features which make the 1936 R&M motors outstanding in performance.

Scores of manufacturers who came to R&M for electrical help even before their appliances had left the inventor's draughting board, have stuck to R&M motors throughout the years, because they know the R&M reputation for furnishing quality motors. Others are constantly turning to R&M to take advantage of our 40 years' experience in building motors to meet unusual service demands.

Our engineering staff and experimental laboratories are at your service too.

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Founded *1878*
Springfield, Ohio • Brantford, Ontario

MOTORS
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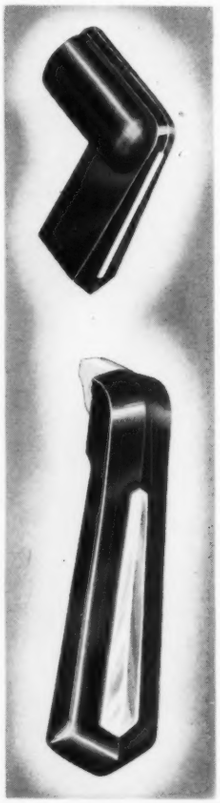

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meet modern trends in product design

The unlimited versatility of shape and size and color in A:R:C molded plastics make it the ideal medium for modern utility and ornamental purposes in today's products. New applications are constantly being developed . . . and each new use suggests another . . . your product, too, may use it to advantage.

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In SPOT *and* SEAM WELDING

Electrodes of

MALLORY METAL 3

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Copper and Other Metals

Make your own comparisons in high speed, long-run production where other electrode materials mushroom rapidly. Then make a complete change over to Mallory 3 Metal—and make a real improvement in production and a worthwhile saving in operation maintenance.

Full details of the superior characteristics of this amazing new alloy will be sent on request—together with interesting facts about water cooling that *really* cools.

Mallory engineers will assist in the solution of your welding problems—without obligation, of course!

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8 Important Advantages are offered in this radically new limit switch

Costs only $6.00

CHECK these big advantages of the new G-E limit switch:

1. ***Two separate circuits,*** one normally open and one normally closed, make it suitable for a wide variety of applications.
2. ***Liberal allowance for overtravel*** — its operating arm can safely turn through 72 degrees.
3. ***Easy to adjust***—by means of its worm-gear precision adjustment, you can lock the operating arm in any position around the shaft.
4. ***Clean, trouble-free contacts*** of the cadmium-plated, double-break type — open and close with a sliding action.
5. ***Easy to install*** — requires no mounting bracket, since the operating arm moves in a plane ***parallel*** to the base.
6. ***Strong, die-cast enclosure*** protects the mechanism. Handy conduit connection and removable cover plate are provided.
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There are dozens of jobs that this new, low-priced limit switch can do for you. It supplies a simple and convenient means of interlocking mechanical motion with electric control circuits, for making processes automatic, operating safety devices, etc. Put it to work on your machines and watch it save money.

Our experienced engineering staff will gladly co-operate with you to put G-E limit switches to work profitably on your machines. For complete information, mail the coupon to General Electric, Dept. 6L-201, Schenectady, N. Y.

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This new limit switch is one example of General Electric's constant activity in advancing modern methods to protect men and machines. Soundness in design, manufacture, and application has made General Electric HEADQUARTERS FOR INDUSTRIAL CONTROL.

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PROFITABLE modernization of machines, devices and appliances requires the best of inventive talent and engineering knowledge. Of equal importance is the reliance placed upon new and modern materials to develop products into more useful and saleable form.

Modern Bakelite Materials offer manufacturers three-fold assistance in redesigning their product. They make possible a new, and distinctive appearance. They usually simplify production methods. They frequently improve mechanical design.

To the improved appearance of products, Bakelite Materials contribute rich color, permanent lustre and ready adaptability to line and form. In production, they offer important economies, such as the elimination of polishing and finishing operations. To mechanical design they furnish strength, light weight and durability, combined with superior chemical, thermal and electrical properties.

Manufacturers are urged to study their own products with a view to improving the design, construction and saleability through the use of Bakelite Materials. We shall be glad to cooperate in determining the possibilities. For full facts about Bakelite Materials and their varied applications, write for Booklets **5M,** "Bakelite Molded" and **5L,** "Bakelite Laminated".

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1910 — SILVER ANNIVERSARY — 1935

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Imperial Pencil Tracing Cloth

Try it!

■ Made with the same uniform reliable base cloth as used in IMPERIAL tracing cloth.

But has a special dull drawing surface on which lines made even with a hard pencil, appear sharp and opaque.

As suitable for ink work as the well-known IMPERIAL tracing cloth.

Pencil lines will not smudge, but erasures can be easily made without damaging its surface.

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A PRODUCT OF THE MANUFACTURERS OF THE WORLD RENOWNED IMPERIAL TRACING CLOTH

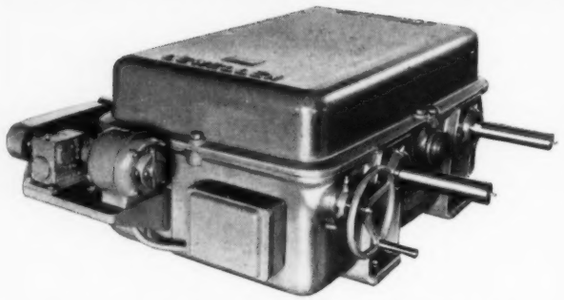
IMPERIAL PENCIL TRACING CLOTH

REG. U.S. PAT. OFF.

for Sale by

LEADING Stationery and Drawing Material Dealers ◆ ◆ EVERYWHERE

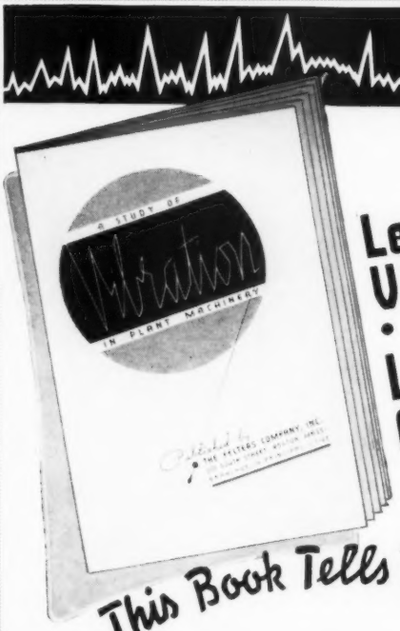
LEWELLEN



VARIABLE SPEED TRANSMISSIONS
AUTOMATIC ELECTRICAL CONTROLS

Above illustration shows a No. 12 completely enclosed Lewellen Transmission with electrical controls. This transmission and controls automatically maintain a uniform weight or thickness of insulating felts made from rock wool or slag. The controls are adjustable to maintain any predetermined weight or thickness. Just one of many special variable speed control problems which Lewellen engineers have solved in recent months. They can do the same for you. Just give us the essential data of horsepower, speeds, etc., with a sketch or drawing of your machine. We will submit blue prints, prices, etc., for your consideration.

LEWELLEN MFG. CO.
COLUMBUS, IND.



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This Book Tells You How

For years vibration in rotating and reciprocating machinery has been regarded as an unescapable evil—a costly consort to production. But exhaustive researches have proven that vibration with all its economic waste can be greatly lessened. These facts, as they were developed from our research, are embodied in a new book, "A Study of Vibration in Plant Machinery." Send for a copy. It's yours for the asking.

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"How can we get closer control of temperature in our embossing press?"

The simple answer was **CHROMALOX ELECTRIC HEATING UNITS**

"Uniform quality production is now impossible due to temperature variation, while gas fumes affect the operator. Will electric heat help us?"

The CHROMALOX solution:

"Eight 750-watt strip heaters, placed where the present heating equipment is located, and controlled by a thermostat. Drill a hole in the embossing plate for the sensitive bulb of the thermostat."

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Position .....

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Don't penalize the efficiency and reputation of your machines with "tenderfoot" bearings. Particularly when it costs no more to use CJBs—the custom built quality bearings with no price premium. Specially selected steel and extreme accuracy of workmanship assures smooth operation, economy of power and long life.

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BALL BEARINGS

A fourteen-inch stamping

For more definite detail of design,
" variety and beauty of finish,
" greater strength and less weight,
" lower unit cost and die investment,
" quicker deliveries and service.

CHANGE from die castings to

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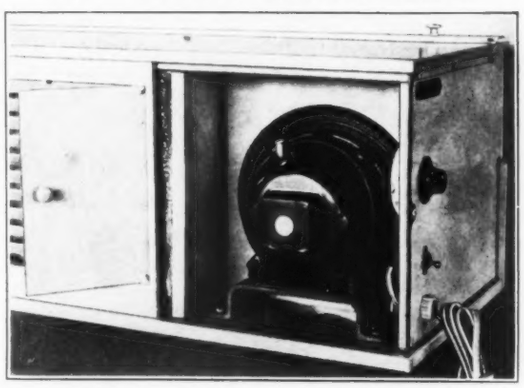
HOLTZER-CABOT MOTORS

FOR AIR CONDITIONING UNITS



QUIET • RUGGED • DEPENDABLE

Manufacturers of motor driven apparatus and appliances have found Holtzer-Cabot Motors built to fit the job, give best results. Our engineers have a wealth of experience. Let them shoulder your motor problems.

WRITE DEPT. 12 FOR COMPLETE INFORMATION

HOLTZER-CABOT ELECTRIC CO.
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Keep SPECIAL ROLLED SECTIONS *in mind*

IN designing parts to be turned out on a quantity-production basis, it is well worth while to view them in the light of bar-mill capabilities. Often it happens that the design can be adapted to manufacture from special rolled sections.

Bethlehem pioneered this type of steel product and has rolled a wide variety of difficult sections. If a section can possibly be rolled, it can be rolled in the Bethlehem Bar Mills.

So great are the savings sometimes realized by the use of special rolled sections that we suggest a careful review of the parts of your product with an eye to this economical method of manufacture.

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Bethlehem Steel Company
General Offices: **Bethlehem, Pa.**

Bethlehem District Offices are located at **Atlanta, Baltimore, Boston, Bridgeport, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Houston, Indianapolis, Kansas City, Milwaukee, New York, Philadelphia, Pittsburgh, San Antonio, St. Louis, St. Paul, Washington, Wilkes-Barre, York.** ***Pacific Coast Distributor:*** **Pacific Coast Steel Corporation, San Francisco, Seattle, Los Angeles, Portland, Salt Lake City, Honolulu.** ***Export Distributor:*** **Bethlehem Steel Export Corporation, New York.**

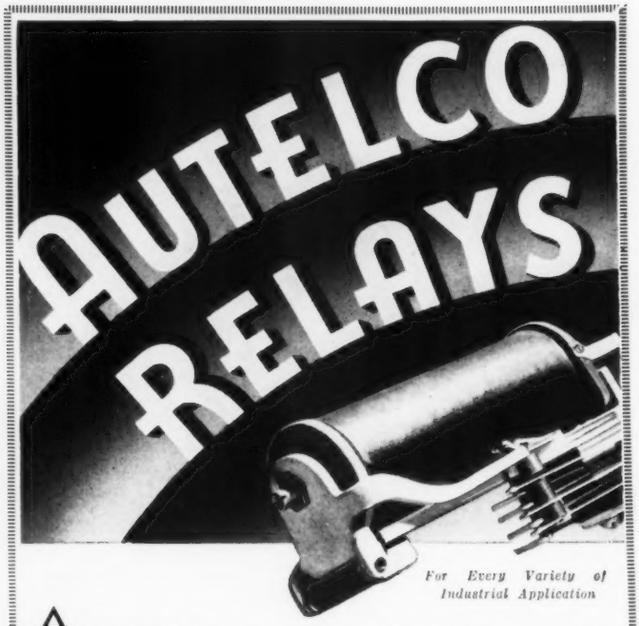
CELORON SPOKE GEARS

- ABSORB
- SHOCKS

Actual running tests, load and overload, speed and many other tests have been made on gears of various types and sizes operating under identical conditions—all proving that Celoron Spoke Gears absorb shocks, minimize tooth wear, reduce noise, save maintenance, increase machine productivity.

These facts and figures are all a matter of record which we would like to discuss with you.

CONTINENTAL-DIAMOND FIBRE CO.
NEWARK, DELAWARE



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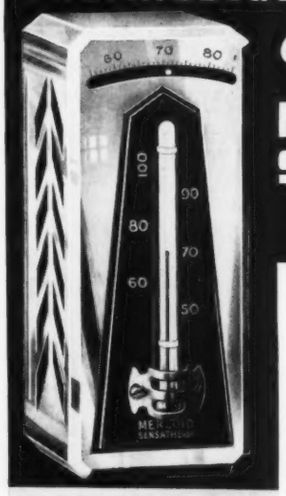
AUTELCO Relays have a unique history which particularly commends them for uses where ***reliability of operation*** is paramount. Forty years of design and manufacture for the exacting requirements of the telephone industry have resulted in a variety of perfected relay types which are now being applied with equal success to industrial requirements of every kind. Send for catalog 4016-A—free upon request—which gives a complete description of types available.

AUTOMATIC ELECTRIC COMPANY...Chicago, Illinois

"WE USE CHACE Thermostatic BIMETAL Exclusively IN THE MERCOID SENSATHERM"



THE MERCOID CORPORATION

With the slightest change in temperature, highly sensitive Chace Thermostatic Bimetal units move to make or break electric contact, thus automatically setting to action such other mechanism as results in room temperatures exactly to our liking.

If control of temperature is your problem or if you wish to have temperature changes perform automatic duties we suggest that you investigate Chace Thermostatic Bimetal. ***Sold in Sheets, Strips or Formed to Specifications.***

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"It Bends with the Heat"

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A COUNTING DEVICE TIPPED THEM OFF—

TROUBLE AT THE NIGHT BOX

Many banks have small vaults accessible from the street for night or week-end deposits of merchants. One vault manufacturer builds-in a Veeder-Root counting device which records the number of deposits made. In the morning the counter's record is checked against the actual number of deposits reported by the bank employees who open the vault. If they don't agree, it means trouble — *quick* trouble for the crook.

It pays to investigate Veeder-Root Counters — pays very well. By building counting devices into his product many a manufacturer has boosted his sales. In this group are gasoline pumps, conveyors, cameras, tractors, elevators, typewriters — *and there are many other products that could use counters just as profitably.*

It is a fact that the most profitable counter applications are obvious only after they are made.

Look at your product with a creative eye. If it could be improved through the use of a built-in counting device, Veeder-Root will put the experience and facilities of the world's largest and oldest counter-building organization at your service. *Write.*

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HARTFORD, CONN., U. S. A.
Factories in Hartford and Bristol, Conn.
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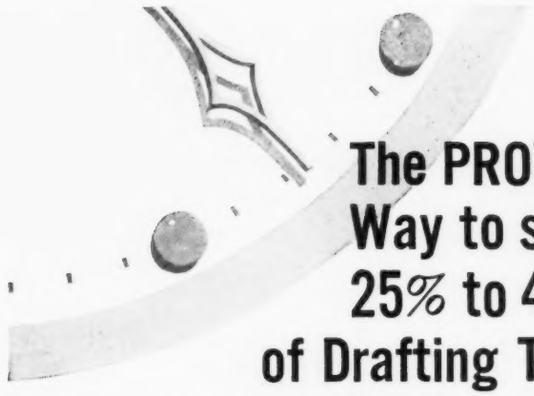
VEEDER-ROOT INC.

COUNTERS FOR EVERY PURPOSE

2041



The PROVED Way to save 25% to 40% of Drafting Time

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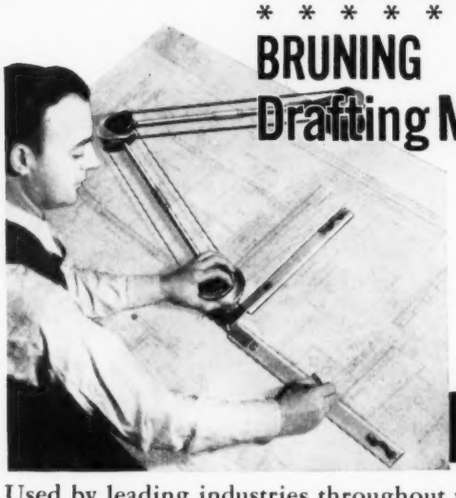

Used by leading industries throughout the country—tried and tested in drafting rooms from coast to coast—the Bruning brings you PROVED savings of 25% to 40% in drafting time.

Designed with thorough knowledge of drafting conditions, this machine entirely eliminates the separate use of triangle, T-square, scales and protractor . . . produces more accurate drawings than old-fashioned methods. Made in both standard and civil engineers' models, it demonstrates its worth in any drafting room.

Once you try a Bruning Drafter, you will never again be satisfied with hand drafting. Take the *sure* way to lower drafting costs—mail the coupon for complete facts about the Bruning Drafter.

BRUNING

—Leading the field today in sensitized papers, reproduction processes, drawing material and drafting room equipment.

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I want to know more about the Bruning Drafter. Please send me, without obligation, the money-saving facts.

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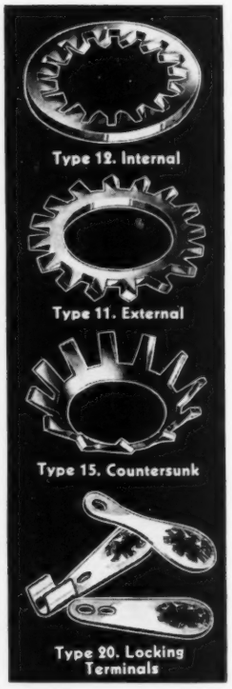
SHAKEPROOF

The New Cars are SHAKEPROOF *of course!*



IT seems the new cars have reached a zenith. Such performance! Such riding comfort! And, at prices so surprisingly low! Shakeproof is happy to have played a part in this great display of automotive progress and is proud that the industry has specified Shakeproof Lock Washers for an even greater number of applications than ever before. The engineers who are designing and building these great cars know from years of experience that Shakeproof's multiple-locking washers never let go—that each twisted tooth, biting into both nut and work surfaces, positively stops any backward movement of the nut. That is why they depend on Shakeproof to keep important connections tight and thus assure the utmost in performance.

SHAKEPROOF

Lock Washer Company

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Distributors of Shakeproof Products
Manufactured by Illinois Tool Works
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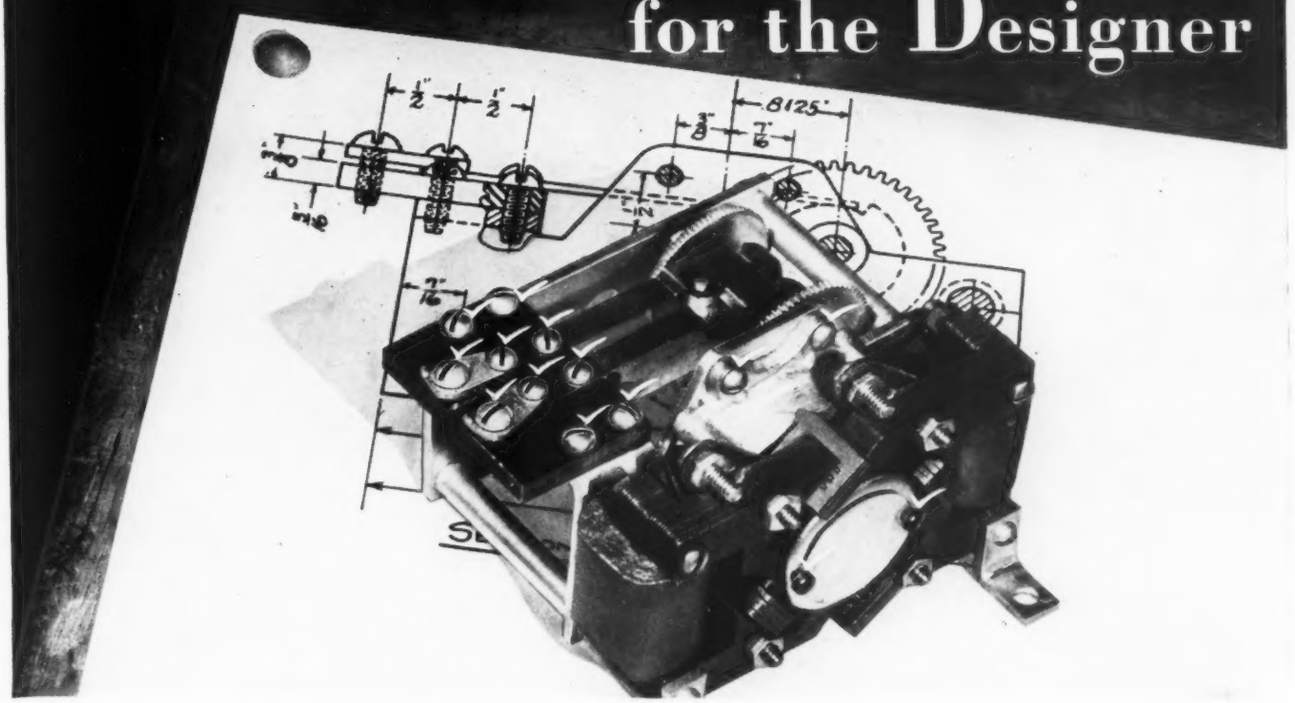
CHALK ONE UP for the Designer



—*He saved 25% on these Timer fastenings by specifying Self-tapping Screws*

"Use bolts and nuts here . . . use machine screws in tapped holes there." It would have been easy for the designers of this Timer to write that hasty and conventional assembly specification after completing the electrical and mechanical features. However, assembly methods received careful instead of hasty consideration. And the result was a 25 percent saving on the fastenings!

Comparison showed that adoption of Parker-Kalon Type "Z" Hardened Self-tapping Screws instead of machine screws would eliminate the costly operation of tapping the brass parts. Also that these same unique Screws would save time and labor as compared with bolts and nuts for fastening contact springs to the Bakelite panel. Cheaper to use for both assemblies, the Type "Z" Self-tapping Screws made the assemblies stronger, too. *They always hold better under tension, shear and vibration than machine screws in tapped holes, or bolts and nuts.*

Many designers and production heads make it a practice to consider Self-tapping Screws whenever a fastening problem arises. While these Screws will not make every fastening cheaper and stronger, records do show that *in seven out of ten cases they provide a better job for less money.* So high an average of success makes it important for you to investigate the opportunities on your own jobs. Do it now. Send a brief description of one or more specific fastenings with the coupon. We'll furnish FREE samples of the correct type of Self-tapping Screw for a trial, with recommendations of our Assembly Engineers.

PARKER-KALON
HARDENED
Self-tapping Screws
PAT. IN U.S. AND FOREIGN COUNTRIES

Where and How to use:-

Type "Z" Hardened Self-tapping Sheet Metal Screws

For joining and making fastenings to sheet metal up to six gauge; aluminum, die castings, Bakelite, etc. Simply turn Screw into drilled, pierced, molded hole. It forms a thread in the material as it is turned in. Can be removed and replaced.

Type "U" Hardened Metallic Drive Screws

This type of Self-tapping Screw is used for making permanent fastenings to iron, brass and aluminum castings, steel, Bakelite, Durez, etc. Hammer Screw into a drilled or molded hole. It forms a thread in material as it is driven.

Parker-Kalon Corp. P.196 Varick Street, New York

Send samples of Self-tapping Screws suitable for fastenings described on attached sheet

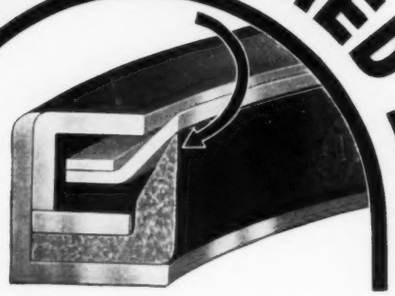
Name .....

Company .....

Address .....

Parker-Kalon Products are sold only through recognized distributors

THE TAPERED EDGE



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The tapered edge of the leather washer is a vital feature of the Gits Precision Oil Seal.

The leather is so flexible at this tapered edge that only a slight pressure of the flat spring clamp ring, located at this point, is required. Friction on the shaft is therefore reduced to a minimum. Moreover this sharp tapered edge prevents the escape of oil by shearing the oil film.

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For Every
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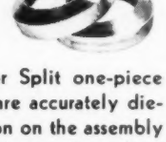

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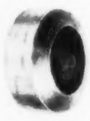

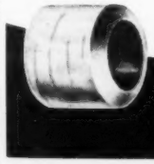

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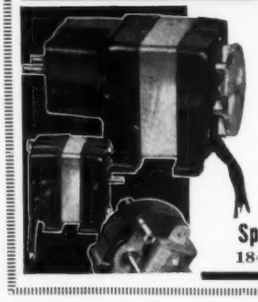

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2
WE HAVEN'T ANY JOBS, WHAT'S THE USE OF DOING ANYTHING. LET'S GO SIT IN THE PARK
3.
BOYS, YOU KNOW WHEN I LOST MY JOB, I DESIGNED A NEW CLUTCH AND SOLD QUITE A FEW
4
NOW, I'M GOING TO START MAKING THEM UP MYSELF. YOU BOYS HAVE WORKED IN MACHINE SHOPS — COULD ONE OF YOU RUN MINE ?
5.
I WOULDN'T WANT TO TAKE A CHANCE, MR. SMITH. I KNOW MY OWN WORK, BUT THERE'S A LOT, ABOUT TOOL-MAKING, FOR INSTANCE, I WOULDN'T KNOW HOW TO HANDLE
6.
SAY, I'LL TRY IT MR. SMITH. I'VE LEARNED A LOT ABOUT THAT IN MY SPARE TIME AND IF I JUST KEEP RIDING ALONG WITH MY AMERICAN MACHINISTS' LIBRARY I'M SURE I CAN HANDLE IT
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the experience of others as found in books

What do you do when tough questions come up on the job—for special study—to prepare for advancement—to find quicker, better, easier ways to do things—to meet any situation that faces the man with an ambitious interest in his job? Are you content to take experience as it comes, or are you taking the short road, through the other man's experience? Hundreds of men who have fared best under upset conditions and growing competition have found that there's *pay dirt*—good-as-gold knowledge—in the rich store of ideas, facts, experience accumulated by experts and made available to all in:

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This library offers you every bit of information you need to progress in tool and gage work—machine tool operation—jigs and fixtures—punches and dies—working of steel—in fact everything you are likely to encounter if you aim for better results, more practical knowledge, a bigger edge over competition, better ability, and advancement in machine shop work.

These books give you exact information regarding the principle involved in operating lathes, drills, hand and automatic screw machines, planers, boring machines, milling machines, etc. They tell you how to operate these machines expertly. Just the kind of information you need!

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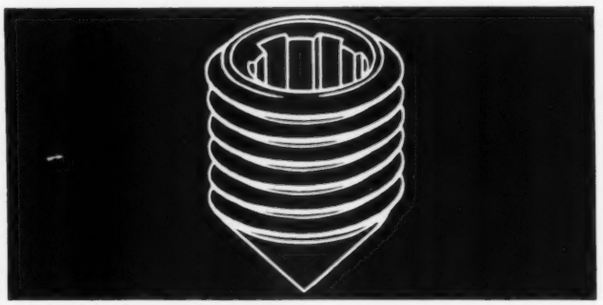

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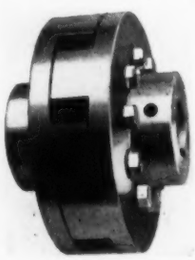

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"Gear Within a Gear . . . Two Moving Parts"

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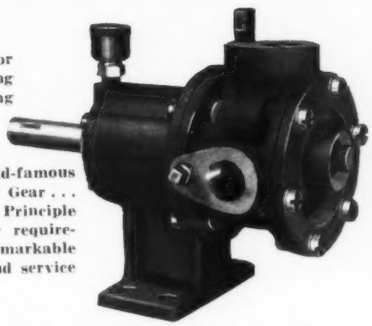

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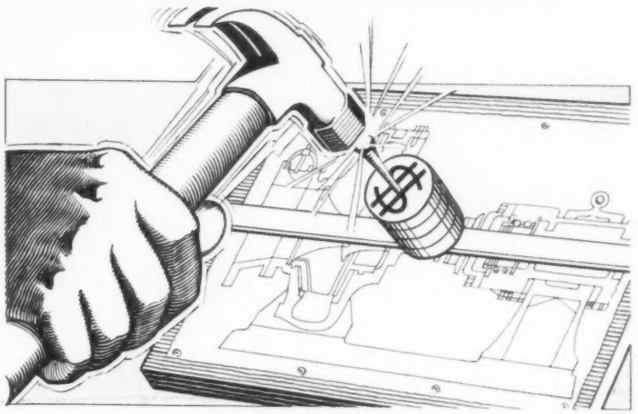
THEY *nailed* PRODUCTION COSTS AT THE PACKING POINT*



Before the design could become a practical finished product, a packing was needed. The problem was so tricky that no packing then on the market would meet the requirements.

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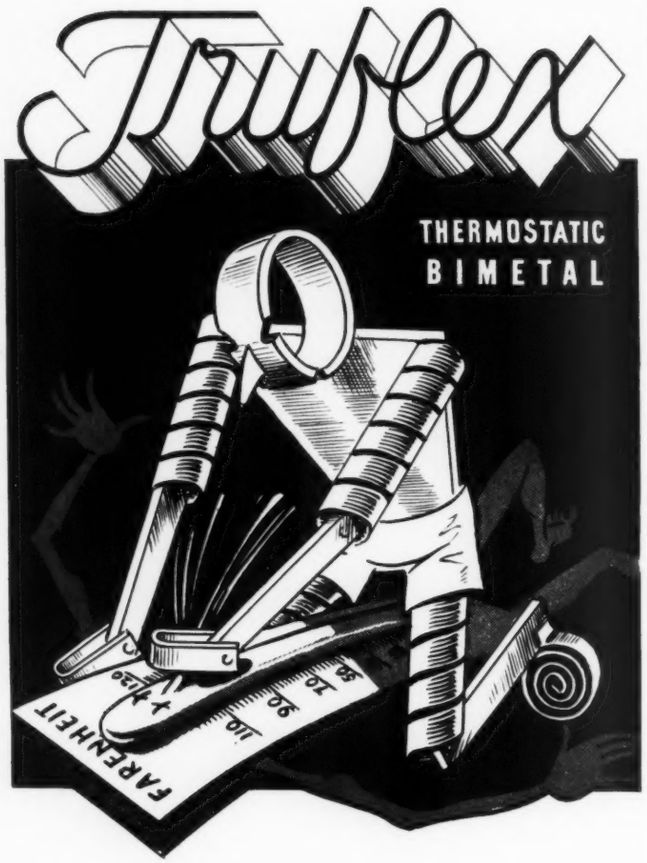
*—The "Packing Point" is the point in the design of a machine where the problem of packing enters—the point where, we suggest, you consult The Home of Research.

"Creating Success at the Packing Point"

2105



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GENERAL PLATE CO.

ATTLEBORO, MASSACHUSETTS

2044

INDEX TO ADVERTISERS

	Page
Ahlberg Bearing Co.	30
Allen Mfg. Co.	24
Aluminum Co. of America	9
American Brass Co.	19
American Emblem Co.	31
American Record Corp.	26
Automatic Electric Co.	32
Baldor Electric Co.	24
Bakelite Corp.	28
Bender Warrick Corp.	38
Bethlehem Steel Co.	31
Bristol Company	38
Bruning Co., Inc., The Chas.	34
Carnegie-Illinois Steel Co.	22
Chace Valve Co., W. M.	32
Climax Molybdenum Co.	21
Continental-Diamond Fibre Co.	32
Crane Packing Co.	36
Cullman Wheel Co.	38
Dahlstrom Metallic Door Co.	8
Dow Chemical Co.	Back Cover
Felters Company, Inc.	30
General Electric Co.	11, 18, 27
General Plate Co.	40
Gits Bros. Mfg. Co.	36
Graton & Knight Co.	39
Hilo Varnish Corp.	12
Holtzer Cabot Electric Co.	31
Hyatt Roller Bearing Co.	23
Imperial Tracing Cloth	29
Imperial Electric Co.	36
International Nickel Co.	Inside Front Cover
Lewellen Mfg. Co.	30
Linde Air Products Co.	13
Lovejoy Tool Works	38
McGraw-Hill Book Co., Inc.	37
Mallory & Co., Inc., P. R.	26
Morse Chain Co.	7
National Carbon Co.	14
New Departure Mfg. Co.	5
Norma-Hoffmann Bearings Corp.	15
Parker-Kalon Corp.	35
Parker-Rust Proof Co.	20
Professional Services	39
Reeves Pulley Co.	6
Riverside Metal Co.	4
Robbins & Myers, Inc.	26
Scovill Mfg. Co.	3
Seymour Mfg. Co.	25
Shakeproof Lock Washer Co.	34
SpeedWay Mfg. Co.	36
Spring Washer Industry	17
Square D Co.	Inside Back Cover
Standard Pressed Steel Co.	36
Timken Roller Bearing Co.	16
Toledo Synthetic Products, Inc.	10
Union Carbide & Carbon Co.	13
Veeder-Root, Inc.	33
Viking Pump Co.	39
Wiegand Co., Edwin L.	30

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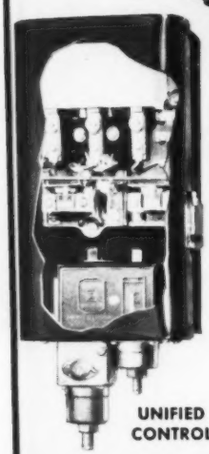

UNIFIED
CONTROL

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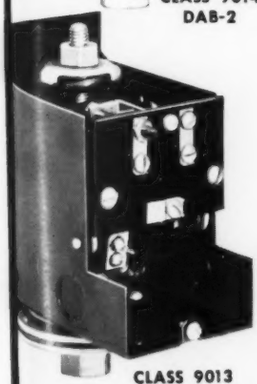
DAB-2



CLASS 9013
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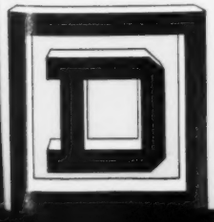

■ When it's a pressure switch that's required to make your product complete—whether it's a simple pump or an elaborate piece of mechanism—call for it by the Square D number. ■

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. . . tons of coal to be sprayed with calcium chloride under pressure as a dust treatment. A pressure control for this service needed. Where will we get it?

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. . . an air conditioning job—crowded quarters, all control must be compact. Separately mounted devices not practical. What's the answer?

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. . . a corner service station badly in need of explosion-proof, cast iron pressure switch as a safety measure. Who can supply this?

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. . . modern Diesel locomotive needs accurate, rugged oil pressure control in cab as safety device. Who can furnish it?

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. . . a heating job—vacuum return system. Vacuum switch needed with Manual On and Off and Automatic lever. Who builds such a device?

SQUARE D—CLASS 9013-V WITH 9039-W8 THREE-WAY LEVER

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. . . automatic fire sprinkler system—pressure must be signaled at dangerous extremes. Whom will we call?

SQUARE D—CLASS 9013 TYPE PS-1 PRESSURE SIGNAL

•

. . . garage type air compressors—tough, frequent service, high pressure, bleeder valve wanted with switch. Who can supply it?

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. . . or what is your problem—from a filling station to a world-famous production line? Square D can supply the need. Call in a Square D Man.

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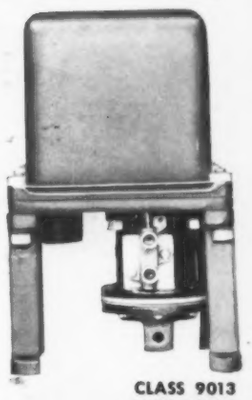
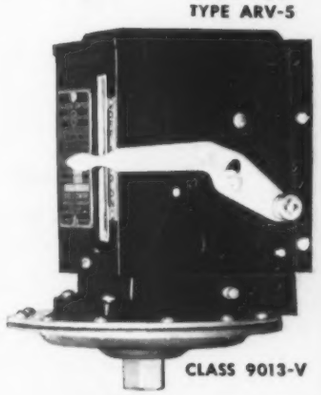
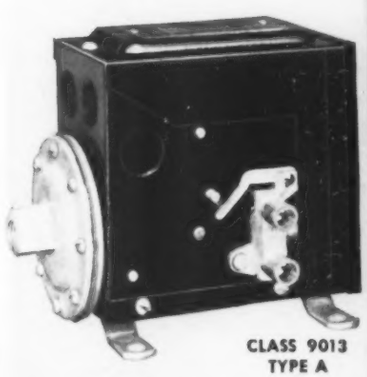


CLASS 9013
TYPE ARV-5



CLASS 9013-V



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TYPE A

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Out of the Black Hills of South Dakota comes another thrilling Dowmetal achievement! This time, Dowmetal's lightness and strength aided Capt. Albert W. Stevens and Capt. Orvil A. Anderson in adding another 12,764 feet to valuable stratosphere exploration! 74,000 feet in all!

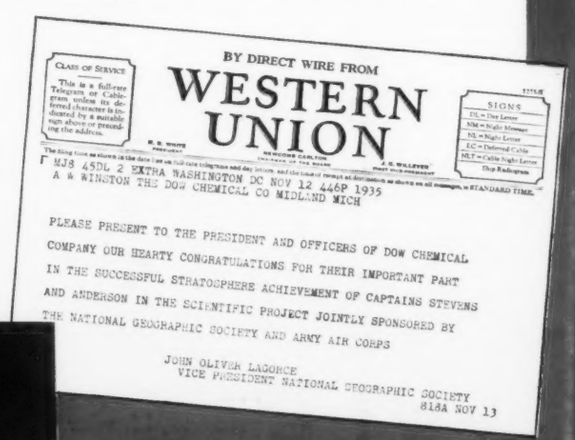
Not all Dowmetal achievements are as spectacular as this National Geographic and U. S. Army sponsored stratosphere flight. Wherever Dowmetal is used, however, its lightness and strength permit doing many hitherto impossible things.

Vehicles are made lighter. Deadweight is lessened. Payload is increased. Operating costs are reduced. Portable tools are made lighter . . . easier to handle . . . less tiring . . . safer. Vibration, friction, noise and wear are minimized in fast-moving mechanical parts that spin or turn. Heavy, inert objects that men lift and move laboriously are made lighter and easier to handle. Production is quickened.

Write for interesting book, "Dowmetal —Lightest of All Structural Metals."

THE DOW CHEMICAL COMPANY • Dowmetal Division • Midland, Michigan

Dowmetal gondolas have made several stratosphere flights: Settle and Fordney in 1933; Kepner and Stevens in 1934; and Stevens and Anderson in 1935. These gondolas contain Dowmetal in practically every standard form . . . welded rolled plates, castings, extruded sections, and forgings.



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PLEASE PRESENT TO THE PRESIDENT AND OFFICERS OF DOW CHEMICAL COMPANY OUR HEARTY CONGRATULATIONS FOR THEIR IMPORTANT PART IN THE SUCCESSFUL STRATOSPHERE ACHIEVEMENT OF CAPTAINS STEVENS AND ANDERSON IN THE SCIENTIFIC PROJECT JOINTLY SPONSORED BY THE NATIONAL GEOGRAPHIC SOCIETY AND ARMY AIR CORPS

JOHN OLIVER LAGORCE
VICE PRESIDENT NATIONAL GEOGRAPHIC SOCIETY
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